

**ECONOMIC ANALYSIS  
FINAL RULE**

**ALLOW FRESH HASS AVOCADOS GROWN IN APPROVED ORCHARDS IN  
APPROVED MUNICIPALITIES IN MICHOACAN, MEXICO,  
TO BE IMPORTED INTO ALL STATES YEAR-ROUND  
(APHIS DOCKET NO. 03-022-5)**

**U.S. Department of Agriculture  
Animal and Plant Health Inspection Service**

**November 5, 2004**

## SUMMARY

This analysis addresses near-term economic impacts of a rule that will allow fresh Hass avocados from Mexico to be imported into all of the United States throughout the year with importation into California, Florida, and Hawaii delayed for two years. The United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) is proposing this action at the request of the Government of Mexico. Economic effects of the rule are analyzed as required by Executive Order 12866. Possible impacts for small entities are considered in accordance with the Regulatory Flexibility Act.

Impacts are analyzed using a partial equilibrium model. Expected near-term effects of two alternatives are compared: 1) Allowing Hass avocados from Mexico to enter all States year-round except California, Florida, and Hawaii, for which entry would be delayed two years (as set forth by the rule); and 2) allowing Hass avocados from Mexico to enter all States year-round with no delay for any States.

The model describes three demand regions and three supply regions for two time periods. The three demand regions are: 31 northeastern and central States (and the District of Columbia) currently approved to receive Hass avocado imports from Mexico during the 6-month period, October 15-April 15 (Region A); 15 Pacific and southern States, excluding California, Florida, and Hawaii, not currently approved to receive Hass avocados from Mexico (Region B); and California, Florida, and Hawaii (Region C). (Mexican Hass avocados have been allowed entry into Alaska since 1993.) The three supply regions in the model are California, Mexico, and Chile. Nearly all U.S. Hass avocado production takes place in California. Over 96 percent of all Hass avocado imports are supplied by Chile and Mexico. The two time periods specified in the model are the six-month period during which Hass avocado imports from Mexico are currently allowed, October 15-April 15 (Period 1), and April 16-October 14 (Period 2). Throughout the following discussion, "avocado" refers only to fresh Hass avocados unless otherwise indicated.

Currently, Mexico is exporting to the United States a fraction of the avocados that could be exported from approved orchards and municipalities in the State of Michoacán. For the market year 2003/04, an estimated 479 million pounds of avocados will be produced in certified areas. During the baseline period, October 15, 2001 to October 15, 2003, annual imports from Mexico totaled 58.2 million pounds, or about 12 percent of what currently could be certified for export to the United States. It is apparent that Mexican producers could readily expand avocado exports to the United States at the current price level. Compared to an average wholesale price during the baseline period in the United States for Mexican avocados of \$1.08 per pound, the average wholesale price per pound in Mexico was \$0.46 in 2001, \$0.37 in 2002, and \$0.46 in (January through October) 2003.

With respect to pest risks, a systems approach currently in place provides multiple safeguards against pest introduction. Risk mitigation measures include pest field surveys; orchard certification; and packinghouse, packaging, and shipping requirements. Since shipments into the conterminous United States began in 1997, cutting and inspection of over 10 million Mexican Hass avocados has not revealed any quarantine pests.

The pest risk assessment for the rule finds an overall low likelihood of pest introduction, concluding with 95 percent confidence that:

- Fewer than 393 infested avocados will enter the 47 States each year.
- Fewer than seven avocados infested with stem weevil, seed weevils and seed moth will enter avocado producing areas outside of California, Florida, and Hawaii each year.
- Fewer than 98 avocados infested with fruit flies will enter fruit fly susceptible areas outside of California, Florida, and Hawaii each year.
- Less than one avocado infested with stem weevil, seed weevils or seed moth will be discarded in avocado producing areas outside of California, Florida, and Hawaii each year.
- Fewer than five avocados infested with fruit flies will be discarded in fruit fly susceptible areas outside of California, Florida, and Hawaii each year.

Even if some infested avocados entered the United States, the likelihood of pest establishment and spread would require that: a) The infested avocados must be in close proximity to host material; b) the pests must find mates; c) the pests must successfully avoid predation; d) the adult pests must find host material; and e) the climatological and microenvironmental conditions must be suitable. These factors substantially reduce the likelihood of establishment. The degree of pest risk reduction attributable to each of the factors has not been quantified. People generally consume the fruit they purchase and dispose of the waste material in a manner (such as in plastic bags that are land-filled or incinerated) that precludes the release of pests into the environment. The economic analysis examines expected effects of the rule and the no-delay alternative without quantifying the very small risk of pest entry and establishment. The difference in risk between the two alternatives is assumed to be negligible.

The rule includes certain changes from existing risk-mitigating requirements. In the approved orchards in Michoacán, Mexico, surveys for the quarantine pests of concern will be increased from annually to semiannually, since the avocados will be allowed to be imported throughout the year. In the packinghouses, a sample of 300 avocados per consignment currently must be selected, cut, and inspected and found free from pests. APHIS is replacing the specific sample size of 300 fruit with a requirement for a biometric sample at a rate determined by the Agency to be appropriate for the size of the particular consignment.

Currently, handlers and distributors are required to enter into compliance agreements with APHIS, as well as satisfy requirements regarding the repackaging of the avocados after their entry into the United States. These requirements are to ensure that handlers and distributors are familiar with the distribution restrictions and other requirements of the regulations, and to ensure that any boxes used to repackage the avocados in the United States bear the same information that is required to be displayed on the original boxes in which the fruit is packed in Mexico.

The repackaging requirements will be maintained. However, APHIS has decided that requiring compliance agreements for 47 States is both untenable and unnecessary. For the two years during which Hass avocados from Mexico will be prohibited from entering California, Florida and Hawaii, there are appropriate safeguards such as fruit and package labeling, regulatory prohibition from importing into and transiting through these three States, and ample penalties for violation of these regulations under the Plant Protection Act.

Currently, Hass avocados from Mexico may enter the United States only at certain ports. These port of entry limitations are intended to work in concert with the shipping area provisions to ensure that the avocados are moved by the most direct route to the approved States where they may be distributed. The port of entry limitations will be revised to allow Hass avocados from Mexico to enter all states except California, Florida and Hawaii. If the avocados are moved by air, the aircraft will not be allowed to land in California, Florida or Hawaii. Hass avocados as residue cargo on maritime vessels will not be offloaded in California, Florida or Hawaii.

Costs related to any of these changes from the current requirements are expected to be small and not significantly influence the supply of Mexican avocados. Costs associated with risk mitigation changes in Mexico will be borne by Mexican entities.

## Alternatives

One alternative would be to leave the regulations unchanged. In this case, access of Mexican avocados would continue to be restricted to the 31 States and the District of Columbia currently approved to receive avocados from Mexico between October 15 and April 15 (and Alaska year-round).

With no rule change, demand for avocados from all three supply regions would continue to increase due to population and income growth, with the relative percentages supplied by California, Chile, and Mexico shifting in response to changes in relative prices and preferences. It is noted that Mexico's avocado exports to the United States have been expanding rapidly (27.9 million pounds in 2001, 58.8 million pounds in 2002, 76.8 million pounds in 2003), as it acquires a larger share of the market in the approved States between October 15 and April 15. During the baseline period (October 15, 2001 to October 15, 2003), more than 68 percent of avocado sales in this region and time period were supplied by Mexico, an increase of nearly 11 percent from its market share between October 15, 2000 and October 15, 2002.

The analysis that follows considers two alternatives to the status quo: The rule, which will allow access of Mexican avocados to all States year-round with a two-year delay for California, Florida, and Hawaii, and the alternative of allowing Mexican avocados to enter all States year-round with no delays.

## The Model

Both the rule, which includes the two-year delay in allowing avocados from Mexico into California, Florida, and Hawaii, and the no-delay alternative are compared to the baseline. Initial quantities and prices used as the baseline for the model are averages for the two-year period,

October 15, 2001 to October 15, 2003. California producer prices are prices "out the packinghouse door" reported by the California Avocado Commission. Chilean and Mexican producer prices are unit import prices reported by USDA Foreign Agricultural Service.

Wholesale price data are taken from prices reported in Wholesale Market Fruit Reports (various issues), by Market News Archive, USDA Agricultural Marketing Service. Prices for Mexican avocados include costs associated with risk mitigation measures. Changes in Mexican avocado costs that may result because of revised risk mitigation measures, such as the increased frequency of orchard surveys and the larger number of approved ports of entry, are assumed to be minor. A fixed Mexican avocado price is assumed throughout the analysis.

The analysis is based on a set of equations that describe, on the demand side, avocado consumption in the United States, and on the supply side, foreign and domestic avocado production for the U.S. market. Demand for avocados in the model is based on a utility function for a representative consumer. On the supply side, the model captures the option of producers to leave ripe avocados on the tree and vary their sale between time periods as relative prices change.

Shift parameters are used in specifying the model's utility function. The shift parameters can be thought of as reflecting non-price influences on demand. As described in the economic analysis, even if avocados from the three supply regions were equal in price, demand for them would not be the same because of consumers' perceptions and preferences. A decrease in the shift parameter for avocados from any of the three supply regions signifies a decrease in demand relative to the demand for avocados from the other regions, for reasons other than a change in price.

Simulation of the changes in Mexican avocado import restrictions as set forth in the rule and the no-delay alternative requires that the model account for year-round access to the newly approved demand regions. New accessibility is represented by changing the shift parameters for these regions from zero values based on current regulatory restrictions, to non-zero values based on consumer preference.

### Effects on Supply and Demand

Expected quantity and price impacts of the rule and the no-delay alternative are shown in table I. With the rule, avocado consumption is expected to increase by 9 percent, from 581 million pounds to 634 million pounds. Quantities supplied by California and Chile will decline by 7.3 percent and 10.3 percent, respectively, while imports from Mexico will increase to 2.6 times their initial level, from 58 million pounds to 154 million pounds. Prices for California avocados will fall by 12.3 percent at the wholesale level (from \$1.63 to \$1.43 per pound) and by 20.6 percent at the producer level (from \$1.02 to \$0.81 per pound).

Under the no-delay alternative, avocado consumption would increase by 13.7 percent, from 581 million pounds to 661 million pounds. Quantities supplied by California and Chile would decline by 12.2 and 16.5 percent, respectively, while imports from Mexico would increase to 209 million pounds, 3.6 times their initial level. California's prices would fall by 20.9 percent at the

wholesale level (from \$1.63 to \$1.29 per pound) and by 34.3 percent at the producer level (from \$1.02 to \$0.67 per pound). Thus, all impacts would be larger in comparison to expected effects with the rule.

Effects by demand region, supply region, and time period are provided by the model. Because overall demand for avocados from California and Chile will decrease in both time periods, wholesale and producer prices for avocados from California and Chile also will decrease in both time periods. With the rule, 62 percent of avocado imports from Mexico will enter during Period 1. Since imports from Mexico during Period 1 will comprise a larger share of total avocado consumption, they will exert greater downward pressure than during Period 2 on prices of avocados supplied by California and Chile. In Region B during Period 1, avocados from Mexico will displace 32 percent of the avocados that had been supplied by California. During Period 2, Mexican avocados will displace 19.5 percent and 20.6 percent of California avocados in Regions A and B, respectively.

Table I. Summary of Near-term Changes in Annual Quantities and Prices<sup>a</sup>

	Initial Prices and Quantities	With Rule <sup>b</sup>	With Alternative to the Rule <sup>c</sup>
	Million Pounds		
Quantity			
Total	581.071	633.542	660.868
Supplied by:			
California	346.011	320.821	303.866
Chile	176.814	158.695	147.695
Mexico	58.247	154.026	209.307
	Dollars per Pound		
Wholesale Price of Avocados Supplied by:			
California	\$1.63	\$1.43	\$1.29
Chile	\$1.29	\$1.20	\$1.15
Producer Price for:			
California	\$1.02	\$0.81	\$0.67
Chile	\$0.59	\$0.49	\$0.44

<sup>a</sup>Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

<sup>b</sup>Year-round entry of Hass avocados from Mexico into all States, except California, Florida, and Hawaii.

<sup>c</sup>Year-round entry of Hass avocados from Mexico into all States.

## Welfare Effects

Price and quantity changes described by the model translate into the welfare changes for U.S. avocado consumers and producers shown in table II. A portion of consumer gains may be captured by retailers exerting market power in setting avocado retail prices. To the extent that this occurs, overall welfare gains are slightly overstated and there is a small deadweight loss.

With the rule, the decrease in California avocado prices due to producers' inelastic supply response will result in gains in consumer utility across all regions and time periods of \$121.7 million. Not surprisingly, consumers in Region A in Period 1 will gain the least, since this is the region and time period already approved to receive avocados from Mexico. Consumer gains in Region B will be greater than in Region C in both time periods, since Mexican avocados will be restricted from entering Region C. Under the no-delay alternative, consumer gains (\$184.5 million) would be over 50 percent greater than with the rule, illustrating the significance of avocado demand in Region C.

Welfare impacts for avocado producers in California and Chile are determined by computing changes in producer surplus based on their avocado factor endowment supply curves. A fall in producer prices will decrease the amount of factor endowment employed in avocado production. Given the decline in producer prices, California avocado producers would experience welfare losses equivalent to \$71.4 million with the rule, and \$114.4 million under the no-delay alternative.

The net change in U.S. welfare is computed by subtracting losses for California producers from consumer gains. As shown, the net welfare gains would be \$50.3 million with the rule and \$70.1 million under the no-delay alternative. Although the no-delay alternative is preferable in terms of net benefits, the two-year delay of entry of Mexican avocados into California, Florida, and Hawaii has been chosen by USDA because it will provide an opportunity for the efficacy of the rule's risk-mitigating safeguards to be demonstrated through year-round distribution to the remaining 47 States, as Mexican avocados currently are only allowed entry during the winter months.

A sensitivity analysis was conducted that considers alternative values for the elasticities of substitution and transformation and California's aggregate supply elasticity in recognition of the uncertainty surrounding the values of these parameters. Because no information is available about their distributions, uniform distributions were assumed. The results of the sensitivity analysis for the welfare effects are given in the standard deviation columns in table II. As shown, the standard deviations for the changes in consumer welfare are small. The standard deviations for the changes in producer welfare are larger, implying greater variability. This greater variability is largely attributable to the wide distribution assumed for California's aggregate supply elasticity in the sensitivity analysis; there is greater uncertainty with respect to the supply elasticity as compared to the demand-based elasticities of substitution. If the change in producer surplus for California avocado producers is normally distributed, the 95 percent confidence interval for their welfare loss with the rule would be (\$45 million, \$102 million), and with the alternative to the rule, (\$76 million, \$158 million).

Table II. Near-term Welfare Gains and Losses<sup>a</sup>

Table II: Near-term Welfare Gains and Losses				
	With Rule <sup>b</sup>	With Alternative to the Rule <sup>c</sup>		
	Million Dollars			
Losses in Producer Welfare	Change in Welfare	Standard Deviation <sup>d</sup>	Change in Welfare	Standard Deviation <sup>d</sup>
California	-\$71.37	\$14.27	-\$114.39	\$20.48
Chile	-\$15.71	\$5.29	-\$24.35	\$5.79
Gains in Consumer Welfare				
Period 1 <sup>e</sup>				
Region A <sup>f</sup>	\$4.02	\$0.99	\$7.84	\$1.18
Region B <sup>g</sup>	\$21.92	\$2.08	\$29.66	\$2.34
Region C <sup>h</sup>	\$14.17	\$3.34	\$27.33	\$2.48
Period 2 <sup>i</sup>				
Region A	\$24.98	\$2.70	\$32.42	\$4.22
Region B	\$31.76	\$3.38	\$41.08	\$5.29
Region C	\$24.81	\$5.29	\$46.12	\$6.34
Total	\$121.66	\$3.61	\$184.45	\$1.93
Net U.S. Welfare Gain <sup>j</sup>	\$50.29	\$14.27	\$70.06	\$20.48

<sup>a</sup>The difference between baseline values and (i) values with the rule and (ii) values with the alternative to the rule.

<sup>b</sup>Year-round entry of Hass avocados from Mexico into all States, except California, Florida, and Hawaii.

<sup>c</sup>Year-round entry of Hass avocados from Mexico into all States.

<sup>d</sup>Standard deviations of the sensitivity analysis distributions.

<sup>e</sup>October 15-April 15.

<sup>f</sup>The 31 northeastern and central States (and the District of Columbia) currently approved to receive Hass avocado imports from Mexico during the 6-month period, October 15-April 15. (Note: Mexican Hass avocados are allowed to enter Alaska year-round.)

<sup>g</sup>Fifteen Pacific and southern States, excluding California, Florida, and Hawaii, not currently approved to receive Hass avocados from Mexico.

<sup>h</sup>California, Florida, and Hawaii.

<sup>i</sup>April 16-October 14.

<sup>j</sup>The sum of welfare losses for California producers and U.S. consumer welfare gains for all regions and both periods.

### Final Regulatory Flexibility Analysis

The Regulatory Flexibility Act of 1980 (Public Law 96-354) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations and small governmental jurisdictions. U.S. businesses that will be directly affected by the rule are Hass avocado producers, handlers and importers.

*Hass Avocado Producers.* An avocado farm is considered small if it has annual receipts of not more than \$750,000. (All small-entity definitions in this analysis are provided in Title 13 of the Code of Federal Regulations, Part 121: Small Business Size Regulations.) Based on 2002 Census of Agriculture data, over 97 percent of California avocado farms are small entities (4,687 out of a total of 4,801 farms). We describe the expected impact of the rule and the no-delay alternative for these small-entity producers in terms of decreases in gross revenue, as derived

from the results of the general analysis. The model indicates that with the rule there will be a 26.7 percent decline in gross revenue, assuming the decrease is proportionally spread across all farms (table III). Under the no-delay alternative, there would be a 42.2 percent decline in gross revenue. The gross revenue declines are attributable more to decreases in price than to decreases in quantity (table IV).

The status quo would be preferable for California's avocado producers, but it would not yield the net benefits to the United States shown to be gained by expanding U.S. access for Mexican avocados. The rule is preferable to the no-delay alternative for California producers. The analysis shows prices for California producers falling by 21 cents per pound and California avocado production decreasing by 25 million pounds under the rule, compared to declines of 35 cents per pound and 42 million pounds if there are no delays (table I). Producer surplus losses—declines in revenue beyond variable costs—are estimated with the rule to be about \$71 million, compared to losses of about \$114 million without the two-year delay (table II). In all respects, California producers will be harmed less when there is a two-year delay for California, Florida, and Hawaii.

Table III. Annual Impact on Gross Revenue for California Hass Avocado Producers

	<u>With Rule<sup>a</sup></u>	<u>With Alternative to the Rule<sup>b</sup></u>
	Million Dollars	
Initial gross revenue (Baseline)	\$354.32	\$354.32
Gross revenue with the rule or alternative to the rule	\$259.58	\$204.73
Decrease in gross revenue incurred by large and small Hass avocado producers	\$94.74	\$149.59
Decrease incurred by small-entity avocado producers <sup>c</sup>	\$59.69	\$94.24
Decrease as a percentage of initial gross revenue <sup>d</sup>	26.7%	42.2%

<sup>a</sup>Year-round entry of Hass avocados from Mexico into all States, except California, Florida, and Hawaii.

<sup>b</sup>Year-round entry of Hass avocados from Mexico into all States.

<sup>c</sup>Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.

<sup>d</sup>The decrease in gross revenue is assumed to be proportionally spread across all producers.

Table IV. Percentage Changes in California Avocado Producer Prices and in Quantities of Avocados Supplied by California

	<u>With Rule<sup>a</sup></u>		<u>With Alternative to the Rule<sup>b</sup></u>	
	<u>Price</u>	<u>Quantity</u>	<u>Price</u>	<u>Quantity</u>
Period 1 <sup>c</sup>	-20.0%	-6.8%	-37.3%	-14.0%
Period 2 <sup>d</sup>	-21.3%	-16.0%	-33.2%	-19.4%

<sup>a</sup>Year-round entry of Hass avocados from Mexico into all States, except California, Florida, and Hawaii.

<sup>b</sup>Year-round entry of Hass avocados from Mexico into all States.

<sup>c</sup>October 15-April 15.

<sup>d</sup>April 16-October 14.

The past decade has seen a decrease in the number of small-entity California avocado producers and in the number of acres harvested. Revenue declines because of the rule are expected to be large compared to losses that small-entity producers may have experienced because of the industry's contraction and growing concentration. California producers will be harmed by the rule, but we cannot predict that a certain number of firms may fail. Each avocado farm draws upon a unique set of human and capital resources and marketing arrangements that define its financial position and prospects. Firm survival will depend on these specific conditions, but in general those small-entity producers with recent histories of small or negative profit margins will be most at risk.

*Handlers.* California Hass avocado handlers (firms engaged in post-harvest activities) will be directly affected by the rule. Companies handling avocados are considered small businesses if their annual receipts are not more than \$5 million. By this definition, 40 out of 51 firms that will be affected by the rule are small entities.

The decrease in producers' revenues will mean a decrease in receipts by small-entity handlers as well. Negative impacts may be at least partially alleviated by additional avocado business activities in Mexico in which U.S. handlers may be involved, but it is unlikely that the smaller firms will have this opportunity. Decreased receipts from reduced avocado sales may also be moderated if the firms are engaged in handling produce other than avocados. Like California producers, affected handlers will benefit from the two-year delay.

*Importers.* Firms that import avocados are defined as small entities if they have 100 or fewer employees. The annual wholesale value of Hass avocados imported by 52 of the 85 firms expected to be affected by the rule is less than \$1 million. We believe these firms are likely to employ fewer than 100 employees and therefore can be considered small. As a group, these firms will benefit from the increase in imports of Hass avocados from Mexico (an increase of nearly 96 million pounds with the rule), but gains will be tempered by reduced imports from Chile (a reduction of about 18 million pounds).

For small-entity Hass avocado importers, the no-delay alternative would be preferable, since it would mean a larger increase in imports (taking into account reduced quantities from Chile): 122

million pounds compared to 78 million pounds with the rule. In either case, importers will benefit compared to leaving the regulations unchanged.

### Longer-term Effects

This analysis describes near-term impacts of two alternatives to current regulations restricting the importation of avocados from Mexico: the rule, which will allow the avocados to enter all States year-round except California, Florida, and Hawaii, for which entry would be delayed two years; and an alternative to the rule, which would allow importation into all States year-round with no delay for any States. The near term may be thought to represent the first year that the rule is in effect. We address here the question of how the alternatives compare in the longer term.

A static, partial equilibrium model is used to depict expected effects of the regulatory change. An initial market equilibrium for avocados was determined based on baseline quantities and prices. Regulatory expansion of access of Mexican avocados into the U.S. market can be thought of as an exogenous shock. The resulting increase in avocado imports from Mexico will lead, in general, to a decline in the prices and quantities of avocados supplied by California and Chile. A new partial equilibrium is attained through regional price and quantity changes, given the parameters of the model.

Whether the effects described in the analysis would be fully realized in the first year of the rule is not known. While the sale of Mexican avocados year-round and the addition of 15 States with the rule (or 18 States under the alternative) will have immediate effects, impacts in the first 12 months may or may not match those described by the model. Changes in buyers' perceptions and preferences—the non-price influences represented by the model's shift parameters—will occur over a period of time. The model does not inform as to how long this transition will take.

If we assume that the effects described in this analysis do occur in the first year, and we assume that the changed supply and demand conditions continue into the second year, then by the end of the second year the effects would be twice those reported in the analysis. When compared to the baseline, the net welfare gain attributable to the rule would be about \$50 million in Year 2, the same as in Year 1, for an undiscounted net gain of about \$100 million over the two years. (The preferred comparison would be one of conditions with and without the rule in Year 2, but the model describes neither of these situations.)

More realistically, by the second year there will be production and marketing responses by California producers to the substantial increase in avocado imports from Mexico. Altered regional marketing strategies and industry promotional activities, for instance, may influence the effects for California producers from Year 1 to Year 2 of the rule (or of the alternative). We do not believe that the new equilibrium described by the model, assumed to be attained in Year 1, will remain unchanged in Year 2.

In Year 3 and afterwards, as long as there are not any pest discoveries that prevent expansion of Mexican avocado imports into California, Florida, and Hawaii, the rule and the alternative are the same. Changes in Year 3 of the rule can be expected to be broadly similar to differences in impact between the rule and the alternative described by the model for Year 1. There will be a

further decrease in producer welfare and increase in consumer welfare, with the latter outweighing the former for an overall net increase in U.S. welfare.

We would not expect the changes in Year 3 to be equal to the differences in impact between the rule and the alternative described for Year 1. Inclusion of California, Florida, and Hawaii will take place two years after the year-round and 15-State expansions have occurred. Two years of Mexican avocado imports into southern and western States may result in regional prices and quantities different from those portrayed by the model. The Year 1 difference between the rule and the alternative in net welfare gains is estimated to be about \$20 million, but the undiscounted net welfare gain in Year 3 of the rule will probably have a different value.

The analysis shows near-term impacts of the rule and the alternative. The period is assumed to represent the first year that the rule is in effect. Differences in impact between the rule and the alternative will continue during Year 2, but are unlikely to be the same as modeled for the first year. The third-year adjustment, when the rule will allow Mexican avocado imports into all States, will remove all distinctions between the rule and the alternative. Effects in Year 3 will be like those indicated by the Year 1 differences in impact between the rule and the alternative, but the quantity, price, and welfare changes are likely to differ from those described by the model for Year 1.

## CONTENTS

1. Introduction	1
2. The Model, Data, and Model Calibration	6
The Model	
Baseline Data	
Model Calibration	
Removal of Import Restrictions	
3. Effects on Supply and Demand	13
A Classification of Effects	
Impacts	
Sensitivity Analysis	
4. Welfare Effects	22
5. Alternatives	24
6. Final Regulatory Flexibility Analysis	27
7. Longer-term Effects	38
References	40
Appendix 1. Model Variables and Equations	41
Appendix 2. A Mathematical Description of the Model and Its Calibration	43
Appendix 3. Baseline Quantity and Price Data	50
Appendix 4. Approach Used for the Sensitivity Analysis	53
Appendix 5. Equivalent Variation	54

**ECONOMIC ANALYSIS  
FINAL RULE**

**ALLOW FRESH HASS AVOCADOS GROWN IN APPROVED ORCHARDS IN  
APPROVED MUNICIPALITIES IN MICHOACAN, MEXICO,  
TO BE IMPORTED INTO ALL STATES YEAR-ROUND  
(APHIS DOCKET NO. 03-022-5)**

**November 5, 2004**

**1. Introduction**

This analysis addresses economic impacts of a rule that will allow fresh Hass avocados from Mexico to be imported into all of the United States throughout the year with importation into California, Florida, and Hawaii delayed for two years.<sup>1</sup> It is a near-term analysis, showing expected effects before access is expanded to all States. We also analyze expected effects of the alternative of allowing Mexican Hass avocados to enter all States year-round with no delay for any States. The rule is in response to a request from the Government of Mexico for increased access of Hass avocados from Mexico into the United States. At present, Hass avocados from Mexico may only be imported into certain States during part of the year.

Economic effects of the rule are analyzed as required by Executive Order 12866. Possible impacts for small entities are considered in accordance with the Regulatory Flexibility Act. In this Introduction, the approach taken in analyzing impacts is described. Section 2 sets forth the model used for the analysis, baseline data, and the model's calibration. Expected effects of the rule on the supply and demand for Hass avocados, and a sensitivity analysis of these results, are presented in section 3. In section 4, welfare effects for U.S. Hass avocado producers and consumers are examined. In section 5, impacts of the no-delay alternative are considered and compared to the baseline. Expected effects for small entities are described in section 6, in a Final Regulatory Flexibility Analysis. Expected effects of the rule in the longer term are described in section 7.

Until relatively recently, entry of Hass avocados from Mexico into the United States was prohibited due to phytosanitary risks. The blanket prohibition was partially lifted in 1993, when the United States Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) authorized their entry into one State, Alaska. Then in November 1997, fresh Hass avocados from Mexico were allowed entry into the conterminous United States for the first time. Entry was allowed into 19 northeastern States and the District of Columbia during a four-month period, November through February.<sup>2</sup> In 2001, the area approved for import was expanded by an additional 12 States, and the period of importation was extended to six months,

---

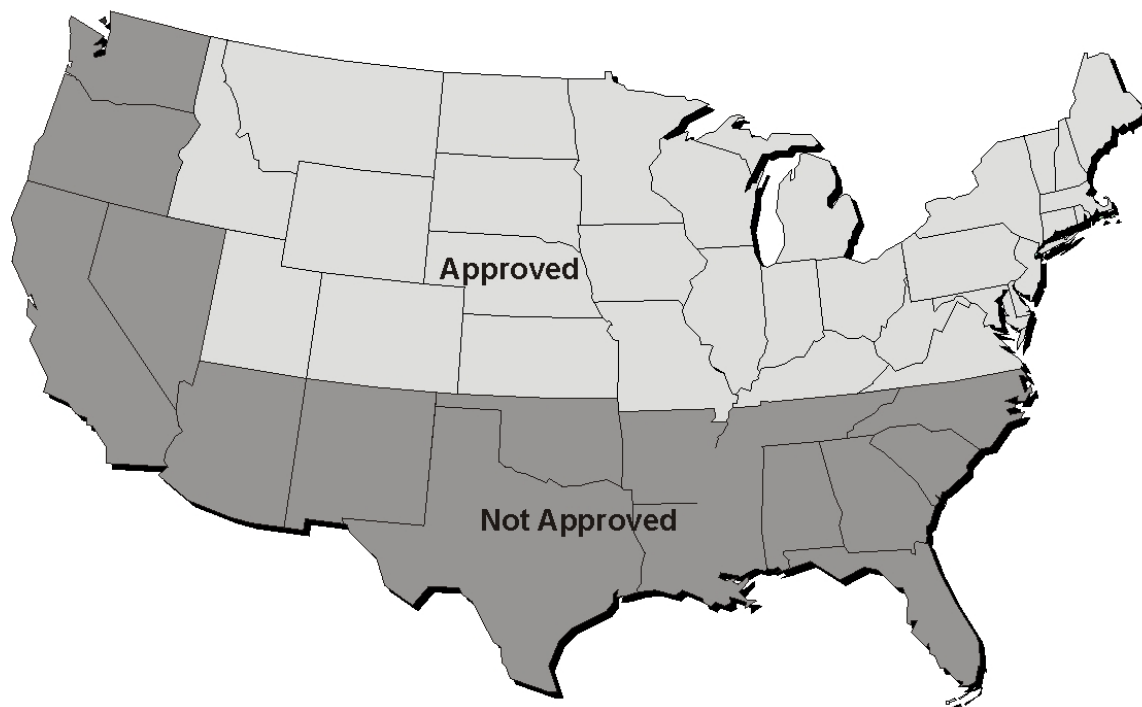
<sup>1</sup> The analysis is the result of collaboration of APHIS economists with Everett Peterson, Associate Professor, Department of Agricultural and Applied Economics, Virginia Polytechnic Institute and State University.

<sup>2</sup> The effective date of the final rule was March 7, 1997. The approved area included Connecticut, Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin.

October 15 to April 15 (figure 1).<sup>3</sup> The rule will allow entry of fresh Hass avocados from Mexico into all States year-round, with entry into California, Florida, and Hawaii delayed for two years.

Impacts of the rule and the no-delay alternative are analyzed using a static, partial equilibrium model. Expected economic effects are examined without quantifying the very small risk of pest entry and establishment. The difference in risk between the two alternatives is assumed to be negligible. Initial quantities and prices used in the model are based on a two-year period, October 15, 2001 to October 15, 2003. The model's framework is summarized in table 1.

**Figure 1. States Approved and Not Approved, as of November 2001, to Receive Fresh Hass Avocados from Mexico between October 15 and April 15**



Note: Alaska is approved to receive Hass avocados from Mexico year-round. Hawaii is not approved to receive Hass avocados from Mexico.

The model has three demand regions: 31 northeastern and central States (and the District of Columbia) currently approved to receive Hass avocado imports from Mexico during the 6-month period, October 15-April 15 (Region A); 15 Pacific and southern States, excluding California, Florida, and Hawaii, not approved to receive Hass avocados from Mexico (Region B); and

---

<sup>3</sup> The effective date of the final rule was November 1, 2001. The States added were Colorado, Idaho, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming.

California, Florida, and Hawaii (Region C).<sup>4</sup> California, Florida, and Hawaii are combined into a separate demand region to capture near-term impacts when Mexican Hass avocados will not be allowed into the three States. Combining the three States into a separate demand region is also reasonable based on rates of avocado consumption. During the baseline period, per capita Hass avocado consumption in California, Florida, and Hawaii is estimated to have been 4.1 pounds per year, compared to 1.1 pounds and 2.3 pounds per year in Regions A and B, respectively.

Table 1. Model Framework

3 Demand Regions	<ul style="list-style-type: none"> <li>• <i>Region A</i> States approved to receive Hass avocados from Mexico between October 15 and April 15</li> <li>• <i>Region B</i> States not approved to receive Hass avocados from Mexico, excluding California, Florida, and Hawaii</li> <li>• <i>Region C</i> California, Florida, and Hawaii</li> </ul>
3 Supply Regions	<ul style="list-style-type: none"> <li>• California</li> <li>• Chile</li> <li>• Mexico</li> </ul>
2 Time Periods	<ul style="list-style-type: none"> <li>• <i>Period 1</i> October 15 to April 15</li> <li>• <i>Period 2</i> April 16 to October 14</li> </ul>

There are three supply regions in the model: California, Mexico, and Chile. Nearly all U.S. Hass avocado production takes place in California.<sup>5</sup> Over 96 percent of all Hass avocado imports are supplied by Chile and Mexico.<sup>6</sup>

Two time periods are specified in the model, given the current six-month restriction on Hass avocado imports from Mexico: October 15-April 15 (Period 1); and April 16-October 14 (Period 2).

Initial quantities and prices used as the baseline for the model are averages for the two-year period, October 15, 2001 to October 15, 2003. Constant elasticities of substitution and transformation are specified, based on demand and supply elasticities derived from the literature, namely: a wholesale-level price elasticity of demand for California of -1.02, an aggregated wholesale-level price elasticity of demand of -0.61, and a price elasticity of supply for California

<sup>4</sup> States not approved to receive Hass avocados from Mexico are Alabama, Arizona, Arkansas, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, Nevada, New Mexico, North Carolina, Oklahoma, Oregon, South Carolina, Tennessee, Texas, and Washington. As mentioned, Hass avocados from Mexico have been allowed to be imported year-round into Alaska since 1993.

<sup>5</sup> Production of the Hass variety in Florida and Hawaii is negligible (Florida and Hawaii Agricultural Statistics Services). About 80 percent of California's avocado production is of the Hass variety (California Avocado Commission).

<sup>6</sup> The percentage is based on import data from the US Census Bureau, July 2001-April 2003. July 2001 was the first month in which Hass avocado imports were distinguished from imports of other avocado varieties.

of 0.35. (Elasticities of substitution and transformation are explained, literature sources are identified, and the derivation of demand elasticities is described in section 2 and appendix 2.)

The elasticities of substitution and transformation are applied to the model's demand and supply equations to replicate the baseline quantities and prices, yielding shift parameter values. The equations are then resolved using different shift parameters to account for the greater access to U.S. markets afforded avocado imports from Mexico under the rule. Resulting changes in prices and quantities provide the basis for approximating welfare impacts for Hass avocado consumers and producers in the United States, and effects for small entities.

The shift parameters can be thought of as reflecting non-price influences on demand. As described in section 3, even if avocados from the three supply regions were equal in price, demand for them would not be the same because of consumers' perceptions and preferences. A decrease in the shift parameter for avocados from any of the three supply regions signifies a decrease in demand relative to the demand for avocados from the other regions, for reasons other than a change in price.

With respect to pest risks, a systems approach currently in place provides multiple safeguards against pest introduction. Risk mitigation measures include pest field surveys; orchard certification; and packinghouse, packaging, and shipping requirements. Since shipments into the conterminous United States began in 1997, cutting and inspection of over 10 million Mexican Hass avocados has not revealed any quarantine pests.

The pest risk assessment for the rule finds an overall low likelihood of pest introduction, concluding with 95 percent confidence that:

- Fewer than 393 infested avocados will enter the 47 States each year.
- Fewer than seven avocados infested with stem weevil, seed weevils and seed moth will enter avocado producing areas outside of California, Florida, and Hawaii each year.
- Fewer than 98 avocados infested with fruit flies will enter fruit fly susceptible areas outside of California, Florida, and Hawaii each year.
- Less than one avocado infested with stem weevil, seed weevils or seed moth will be discarded in avocado producing areas outside of California, Florida, and Hawaii each year.
- Fewer than five avocados infested with fruit flies will be discarded in fruit fly susceptible areas outside of California, Florida, and Hawaii each year.

Even if some infested avocados entered the country, the likelihood of pest establishment and spread would require that: a) The infested avocados must be in close proximity to host material; b) the pests must find mates; c) the pests must successfully avoid predation; d) the adult pests must find host material; and e) the climatological and microenvironmental conditions must be

suitable. These factors substantially reduce the likelihood of establishment. The degree of pest risk reduction attributable to each of the factors has not been quantified. People generally consume the fruit they purchase and dispose of the waste material in a manner (such as in plastic bags that are landfilled or incinerated) that precludes the release of pests into the environment.

The rule includes certain changes from existing risk-mitigating requirements. In the approved orchards in Michoacán, Mexico, surveys for the quarantine pests of concern will be increased from annually to semiannually, since the avocados will be allowed to be imported throughout the year. In the packinghouses, a sample of 300 avocados per consignment currently must be selected, cut, and inspected and found free from pests. APHIS is replacing the specific sample size of 300 fruit with a requirement for a biometric sample at a rate determined by the Agency to be appropriate for the size of the particular consignment.

Currently, handlers and distributors are required to enter into compliance agreements with APHIS, as well as satisfy requirements regarding the repackaging of the avocados after their entry into the United States. These requirements are to ensure that handlers and distributors are familiar with the distribution restrictions and other requirements of the regulations, and to ensure that any boxes used to repackage the avocados in the United States bear the same information that is required to be displayed on the original boxes in which the fruit is packed in Mexico.

The repackaging requirements will be maintained. However, APHIS has decided that requiring compliance agreements for 47 States is both untenable and unnecessary. For the two years during which Hass avocados from Mexico will be prohibited from entering California, Florida and Hawaii, there are appropriate safeguards such as fruit and package labeling, regulatory prohibition from importing into and transiting through these three States, and ample penalties for violation of these regulations under the Plant Protection Act.

Currently, Hass avocados from Mexico may enter the United States only at certain ports. These port of entry limitations are intended to work in concert with the shipping area provisions to ensure that the avocados are moved by the most direct route to the approved States where they may be distributed. The port of entry limitations will be revised to allow Hass avocados from Mexico to enter all states except California, Florida and Hawaii. If the avocados are moved by air, the aircraft will not be allowed to land in California, Florida or Hawaii. Hass avocados as residue cargo on maritime vessels will not be offloaded in California, Florida or Hawaii.

Costs associated with risk mitigation changes in Mexico will be borne by Mexican entities. Changes in Mexican avocado costs that may result because of revised risk mitigation measures, such as the increased frequency of orchard surveys and the larger number of approved ports of entry, are assumed to be minor. A fixed Mexican avocado price is assumed throughout the analysis.

## 2. The Model, Data, and Model Calibration

### The Model

As mentioned in the Introduction, the analysis is based on a static, partial equilibrium model. The model has 34 endogenous variables, 28 exogenous variables, and 34 equations, as shown in appendix 1.

The 34 endogenous variables are (i) the quantities of avocados consumed in each demand region provided by each supply region during each time period, (ii) the wholesale price index in each demand region in each time period, (iii) producer prices in California and Chile in each time period, (iv) quantities of avocados supplied by California and Chile in each time period, and (v) the levels of factor endowment in California and Chile.

The 28 exogenous variables are (i) the populations in each demand region, (ii) per capita incomes in each demand region in each time period, (iii) marketing margins in each demand region for avocados provided by each supply region during each time period, and (iv) the producer price in Mexico (considered the same for both time periods).

The model and its calibration are described mathematically in appendix 2. In this and the following sections, “avocado” refers only to fresh Hass avocados unless otherwise indicated.

*Demand.* The demand for avocados is derived from a weakly separable utility function for a representative consumer.<sup>7</sup> The utility function is assumed to contain two partitions of all goods purchased by consumers: avocados and everything else. In addition, avocados produced in each of the three supply regions are assumed to be heterogeneous products. This assumption rests on observed wholesale price differentials in 14 cities, as described below in the discussion of the baseline data.

Figure 2 shows the assumed preference structure for a representative consumer. There are two different substitution possibilities in consumption. The parameter  $\sigma_2$  represents the elasticity of substitution between avocados from the different supply regions.<sup>8</sup> An increase in the price of California avocados, for example, relative to the prices of avocados from Mexico and Chile will lead the representative consumer to substitute away from the relatively more expensive California product to the relatively less expensive imports.<sup>9</sup> The parameter  $\sigma_1$  represents the elasticity of substitution between avocados from all supply regions and all other goods. An overall decrease in the relative price of avocados (represented by a price index) would lead to the

---

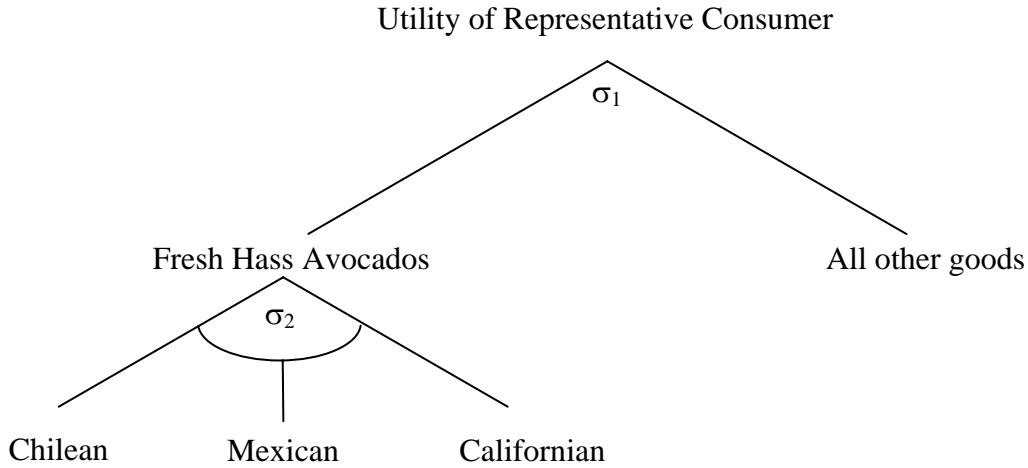
<sup>7</sup>Utility refers to the satisfaction gained from consuming some commodity. A basic assumption of the theory of household behavior is that households seek to maximize their total utility. The assumption of weak separability allows the demand for avocados to be specified as a function of avocado prices, an avocado price index, and total expenditure.

<sup>8</sup>Elasticity of substitution refers to the percentage change in relative demand for two goods (in this case, avocados from different supply regions), given a percentage change in their relative prices.

<sup>9</sup>In a homogeneous goods model,  $\sigma_2$  would equal infinity, that is, avocados from the different supply regions would be perfect substitutes.

representative consumer increasing his or her consumption of avocados from all regions.<sup>10</sup> Thus the value of the parameter  $\sigma_1$  will determine the magnitude of the own-price aggregate demand elasticity for avocados in the model. This determination is discussed in appendix 2.

Figure 2. Preference Structure for a Representative Consumer



A nested Constant Elasticity of Substitution (CES) utility function is used in the model.<sup>11</sup> The main advantage of this functional form is the minimal number of parameters needed to make the model operational: only values for  $\sigma_1$  and  $\sigma_2$  are required to be specified.<sup>12</sup> The main drawback to the CES functional form is that it is homothetic, which implies that all of the income elasticities of demand are equal to one.

*Supply.* Because ripe avocados may be left on the tree for many months before harvesting, it is possible for producers to shift avocado sales between time periods as relative prices change. A Constant Elasticity of Transformation (CET) production possibility frontier is used to capture this possibility.<sup>13</sup> Like the CES utility function, the main advantage of using a CET function is

<sup>10</sup> The price of all other goods is held constant in the partial equilibrium model, and any change in the avocado price index represents a change in relative prices.

<sup>11</sup> A constant elasticity of substitution means that, at all price levels, the percentage change in the relative demand for two goods due to a given percentage change in their relative prices is always the same.

<sup>12</sup> In a general model with  $n$  goods,  $\frac{1}{2}(n)(n-1)$  elasticities of substitution and  $(n-1)$  income elasticities of demand must be specified. For a model with four goods, this would imply six elasticities of substitution and three income elasticities. Because little empirical evidence exists for own-price, cross-price, and income elasticities of demand for avocados, using a more general demand specification would require more ad hoc parameter choices to be made.

<sup>13</sup> The elasticity of transformation is somewhat analogous to the elasticity of substitution. In this case, we have a frontier of all possible production possibilities, for a given factor endowment level. In equilibrium, the relative supply of two goods (or in our case, the relative supply of the same good in two time periods) is dependent on their relative producer prices. Elasticity of transformation refers to the percentage change in the relative supply of two goods (or groups of goods), given a percentage change in their relative prices. A constant elasticity of transformation means that, at all price levels, the percentage change in the relative supply of two goods due to a given percentage change in their relative prices is always the same.

that it is parsimonious in the parameters. Only a single, constant elasticity of transformation must be chosen in order to apply this functional form.

The “supply” of avocados refers to the quantity of avocados sold in the United States. Because the large majority of avocados produced in California are consumed in the United States, the supply of avocados from California is used to represent the total production of avocados in that region.<sup>14</sup> The supply of avocados by Chile and Mexico is an export supply since the U.S. market is only one of several destinations. In the model, avocados supplied by Chile should therefore be more price responsive than avocados supplied by California. This distinction is important when choosing the supply elasticity (aggregated across the two time periods) for Chile, and is discussed further with respect to the model’s calibration.

Currently, Mexico is exporting to the United States a fraction of the avocados that could be exported from approved orchards and municipalities in the State of Michoacán. For the market year 2003/04, an estimated 479 million pounds of avocados will be produced in certified areas.<sup>15</sup> During the baseline period, annual imports from Mexico totaled 58.2 million pounds, or about 12 percent of what currently could be certified for export to the United States. It is apparent that Mexican producers could readily expand avocado exports to the United States at the current price level. Compared to an average wholesale price during the baseline period in the United States of \$1.08 per pound, the average wholesale price per pound in Mexico was \$0.46 in 2001, \$0.37 in 2002, and \$0.46 in (January through October) 2003.<sup>16</sup>

We assume in the model that the export supply of avocados from Mexico is perfectly elastic, and that the price Mexico’s producers receive for their exports is constant (or fixed). We recognize that, in reality, prices in Mexico are not constant, and that this assumption results in a larger level of avocado imports from Mexico than if their demand were modeled as price-responsive. However, price changes are likely to be very small as long as there are large quantities of avocados that meet requirements for sale in the United States but are consumed domestically within Mexico or are exported elsewhere.

## Baseline Data

To implement the empirical model requires specifying a set of prices and quantities that represents an initial equilibrium. These values, shown in appendix 3 table 2, constitute the baseline. All prices and quantities are averages from the two-year period, October 15, 2001 to October 15, 2003. The benefit of using a multi-year base time period is that it reduces the chance of choosing an unusual year. A two-year period is chosen versus a longer base period

---

<sup>14</sup> U.S. avocado exports (all varieties) in 2002 totaled about 23.15 million pounds (U.S. Census Bureau, converted from kilograms). About 95 percent of U.S. avocado exports (all varieties) are produced in California (California Avocado Commission, as reported by UC Davis). California production for the 2001/02 crop year was 399.7 million pounds (California Avocado Commission), yielding an export share of California’s avocado production (all varieties) of 5.5 percent ( $[23.15 \times .95] / 399.7 = 0.055$ ).

<sup>15</sup> USDA FAS, Global Agriculture Information Network, Mexico Avocado Annual Report MX3153 (11/14/2003): 21,400 certified hectares times 10.15 MT per hectare times 2,204.585 pounds per MT.

<sup>16</sup> USDA FAS, Global Agriculture Information Network, Mexico Avocado Annual Reports MX 2170 (12/13/2002) and MX3153 (11/14/2003).

because of the increases in imports from Mexico and Chile in recent years. The baseline is one year more recent than the one that was used in the analysis for the proposed rule.

Quantity data for California avocados, shown in appendix 3 table 1, are based on monthly shipment information provided by the Avocado Marketing Research and Information Center.<sup>17</sup> Quantities of avocado imported from Chile and Mexico are taken from U.S. Census Bureau monthly data. Distribution among the demand regions is described in the notes to appendix 3 table 1.

Wholesale price data are based on prices reported in Wholesale Market Fruit Reports (various issues), by Market News Archive, USDA Agricultural Marketing Service. Wholesale avocado price data were available for Atlanta, Baltimore, Boston, Chicago, Dallas, Detroit, Los Angeles, Miami, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, and St. Louis. During the period October 2001 through September 2003, the average wholesale price for California avocados was \$1.63 per pound, while the average prices for avocados from Mexico and Chile were \$1.08 per pound and \$1.29 per pound, respectively.

California producer prices are prices "out the packinghouse door" reported by the California Avocado Commission. Chilean and Mexican producer prices are unit import prices reported by USDA Foreign Agricultural Service.

The margins between producer and wholesale prices are derived by subtracting the baseline producer prices from the baseline wholesale prices in appendix 3 table 2. For example, the margins in Region A in Period 1 are \$0.60 per pound for California avocados, \$0.53 per pound for Chilean avocados, and \$0.39 per pound for Mexican avocados. The dollar values per pound of all margins are assumed to remain constant in all model simulations.

### Model Calibration

Given the initial values of all prices and quantities in the model, values for parameters in appendix 1 are chosen such that the model can replicate the initial equilibrium while satisfying a set of supply and demand elasticities obtained from the literature. This subsection describes the calibration process.

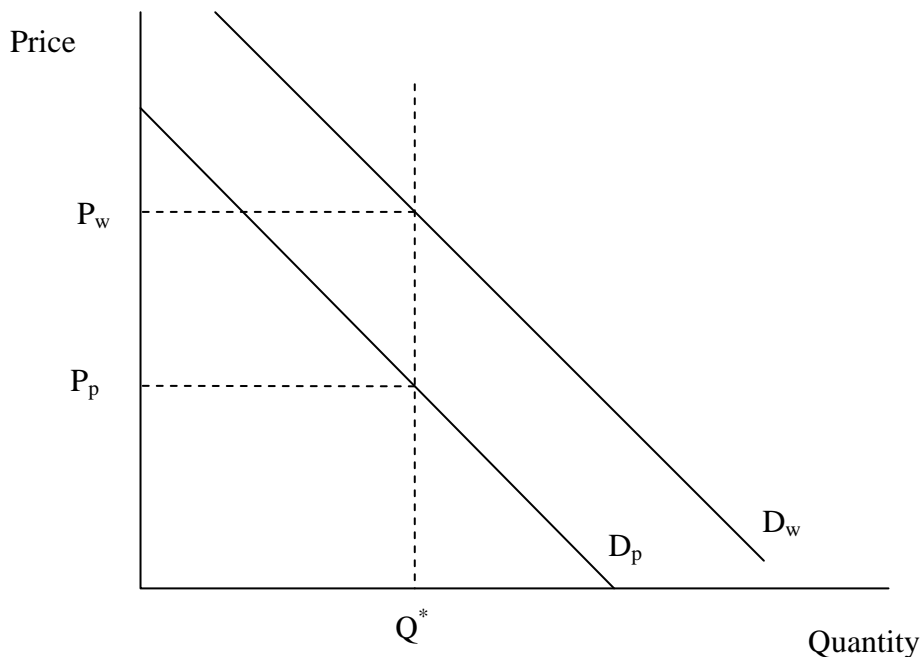
---

<sup>17</sup> AMRIC was created by California state law in 1985 to provide the California avocado industry with daily inventory and shipment information to guide harvest/market strategies.

*Demand Elasticities.* As mentioned, little existing empirical evidence exists on the magnitude of demand elasticities for avocados. Carman and Craft (1998) estimated the inverse demand for California avocados using annual data from 1962 through 1995. They obtained a price flexibility of -1.33 when per capita consumption of California avocados equals 1.012 pounds and the producer price of avocados, deflated by the consumer price index (1982-84 base) equals 51.286 cents per pound. Because per capita consumption and the real producer price in our baseline data differ from those used by Carman and Craft, their flexibility estimate must be adjusted. Using the parameter estimates reported in equation (10) in Carman and Craft, per capita consumption of California avocados of 1.198 pounds and a real producer price of 56.308 cents per pound yields a price flexibility of -1.605, or a demand elasticity of -0.62.

Because the demand elasticity estimate derived from Carman and Craft is for producer prices, it must be adjusted to the wholesale level to be consistent with this model. In making this adjustment, we assume a fixed marketing margin, as illustrated in figure 3. The wholesale-level demand elasticity is obtained by multiplying the producer-level demand elasticity by the ratio of the wholesale price to the producer price. In the baseline data, the average ratio of wholesale price to producer price for California avocados across all markets and time periods is 1.634. Multiplying the implied own-price demand elasticity of -0.62 times 1.634 yields a wholesale-level demand elasticity of -1.02 for California avocados.

Figure 3. Relationship between Producer and Wholesale Demand with Fixed Marketing Margin



The wholesale-level demand elasticity for California avocados is used to determine an aggregate demand elasticity for avocados from all supply regions. This aggregated demand elasticity equals the elasticity for avocados supplied by California times California's share of the total supply. In the baseline data, the average quantity share of California avocados across all demand regions and time periods is 0.595. Thus, the implied aggregate demand elasticity is equal to -0.61.

The values of the demand elasticity for California avocados and the aggregate demand elasticity are used to determine values for  $\sigma_1$  and  $\sigma_2$  (appendix 2 table 1). Once the values of  $\sigma_1$  and  $\sigma_2$  have been determined, the shift parameters ( $a_{1ij}$ ,  $a_{2ij}$ ,  $b_{1i}$ , and  $b_{2i}$ ) can be calculated (appendix 2 table 2). This involves solving a system of non-linear equations.

*Aggregate Supply Elasticities.* Calibration of the revenue functions for California and Chile depends on the assumed elasticity of transformation, that is, the ease with which avocado producers can shift their sales between the two time periods as relative producer prices between the periods change. The factor supply parameters used in the model are shown in appendix 2 table 3. In addition, aggregate supply elasticities for California and Chile determine how easily they can expand or contract total production as the avocado price index changes.

In their study, Carman and Craft estimated that the supply elasticity for California avocados ranged from approximately 0.2 in the short run to a maximum of 1.3 in the long run. Romano (1998) used an aggregate supply elasticity of 0.35 for California avocados. For this analysis, an aggregate supply elasticity for California of 0.35 is used. For Chile, because the relevant supply elasticities are for export supply, not total supply, the aggregate supply elasticity must be adjusted based on the percentage of Chilean production that is exported. During the years 2000 to 2002, Chilean avocado producers exported 54.7 percent of their total production. Thus, the aggregate supply elasticity for Chile is equal to California's aggregate supply elasticity divided by 0.547.

### Removal of Import Restrictions

To simulate the change in import restrictions for Mexican avocados as set forth in the rule requires that Mexico's shift parameters for Region A in Period 2 and for Region B in both periods be adjusted from their initial zero values (appendix 2 table 2). During the periods that Mexican avocados are not allowed to be sold in Regions A and B in the initial equilibrium, the zero values of the corresponding shift parameters are a reflection of current policy rather than a reflection of consumer preferences. When consumers in Regions A and B have access to Mexican avocados year-round, they will undoubtedly purchase Mexican avocados thereby requiring that the demand shift parameters be adjusted to show the effect on U.S. avocado demand. This raises the issue of how to adjust the parameter values of  $a_{1ij}$  and  $a_{2ij}$ .

When adjusting the demand shift parameters, two points must be recognized. First, the use of a CES utility function requires that values of the shift parameters must sum to one. Second, a relatively larger value of a shift parameter represents a stronger preference for that variety by the representative consumer.

Following the work of Venables (1987) on trade policy with differentiated products, we assume that with the change in import restrictions, shift parameter values for avocados from Mexico that are initially zero in Regions A and B can be set equal to the shift parameter values for Chilean avocados. In Region B during Period 1 the shift parameter for Californian avocados is set equal to 0.4 and the shift parameters for Chilean and Mexican avocados are both set equal to 0.3. We assume that the representative consumer will maintain a slightly stronger preference for Californian avocados based on observed prices and market shares in the baseline data. As mentioned earlier, the wholesale prices for Californian avocados exceed the wholesale prices for Chilean avocados in the baseline data. The essentially equal quantity market shares for California and Chilean avocados in Region B during Period 1 indicate a stronger preference for Californian avocados. This is reflected in the initial shift parameters of approximately 0.6 for Californian avocados and 0.4 for Chilean avocados. The stronger initial preferences may be a result of marketing activities by the Californian Avocado Commission or consumer perceptions that fruit from California is fresher than fruit from Chile. Setting both the Chilean and Mexican shift parameters equal to 0.4, the initial value for Chilean avocados, would result in the representative consumer having stronger preferences for Chilean and Mexican avocados than for California avocados. We believe that eliminating the stronger preference for Californian avocados would be unrealistic, particularly given the short time period of the analysis.

In Period 2, the shift parameters for Mexican avocados in Regions A and Region B are set equal to the initial preference parameters for Chilean avocados in the base period. For example, in Region A, the initial shift parameter for avocados from Chile during Period 2 is equal to 0.1755999815 (appendix 2 table 2). With the rule, the shift parameter for avocados from Mexico is also set equal to 0.1755999815, and the preference parameter for California avocados is decreased by the same amount to ensure that the  $a_{2ij}$ 's for this demand region and time period sum to one. The same procedure is used for Region B during the second time period. A larger varietal effect for California avocados is justified in the second time period due to seasonal production patterns. More fresh avocados are available from California than from Chile and Mexico during the summer months.

Because of the assumption that avocados from the supply regions are heterogeneous, the change in import restrictions essentially results in a new variety of avocados becoming available to consumers in Regions A and B. When discussing the model results, we will use the term “varietal effect” to signify the effects of the changes in the shift parameters.

### 3. Effects on Supply and Demand

#### A Classification of Effects

Removal of restrictions on Mexican avocado imports will increase their supply and affect the supply and demand for avocados from California and Chile. Impacts on demand can be decomposed into two price effects and the varietal effect identified at the end of the previous section.

- Demand for avocados from each of the supply regions is affected by changes in relative prices. A decrease in the wholesale price of avocados from California or Chile relative to the price of avocados from Mexico, for example, will increase consumption of the former. This effect on demand of relative changes in wholesale prices is termed the substitution effect. The magnitude of this effect is determined by comparing per capita consumption for avocados in each demand region from each supply region at initial prices, using the changed shift parameters, to per capita consumption at the new prices, holding avocado expenditures constant.
- Similarly, a change in the aggregate price for avocados relative to a composite price for other goods affects their overall demand. A decrease in the price index for avocados from all three regions, for example, will lead to an increase in the demand for all avocados. They become relatively less expensive than other goods (whose price is held constant in the partial equilibrium model). We term this effect the expansion effect, to distinguish it from the first substitution effect and to highlight the impact on their overall demand of a change in the aggregate avocado price. The expansion effect is measured by comparing per capita consumption at initial prices and avocado expenditures, using the changed shift parameters, to per capita consumption at initial prices and the changed level of avocado expenditures.
- Lastly, there is the effect of changes in the utility function's shift parameters  $a_{1ij}$  and  $a_{2ij}$ . Together with the elasticities of substitution, these parameters determine the functional relationship between a representative consumer's utility and his/her consumption of avocados and all other goods (appendix 2 equation 1). As described previously, the effect of a change in the shift parameters can be thought of as a varietal effect that reflects non-price influences on the relative demand for avocados from each of the supply regions. Even if avocados from the three supply regions were equal in price, demand for them would not be the same because of consumers' perceptions and preferences. The term varietal effect is not used in a horticultural sense, but rather in reference to all non-price influences. A decrease in the shift parameter for avocados from any of the three supply regions signifies a decrease in demand relative to the demand for avocados from the other regions, for reasons other than a change in price. The magnitude of this effect is measured by comparing per capita demand for avocados in each demand region from each supply region after the restrictions have been removed (holding prices and income constant), to their initial per capita demand.

## Impacts

Mexican avocados imported for the first time into Region A during Period 2 and into Region B throughout the year will affect the supply of avocados by California and Chile to all of the demand regions. Impacts on quantities and prices are shown in table 2. Overall, avocado consumption is expected to increase by 9 percent. Quantities supplied by California and Chile will decline by 7.3 percent and 10.3 percent, respectively, while imports from Mexico will increase to 2.6 times their initial level, from 58.2 million pounds to over 154 million pounds.

Given producers' inelastic supply, the decline in price is of greater significance for California producers than is the decline in the quantity supplied. California's prices will fall by 12.3 percent at the wholesale level and by 20.6 percent at the producer level. Price impacts for avocados supplied by Chile will be smaller, since their initial price is closer to that of Mexican avocados.

Effects by demand region, supply region, and time period are provided by the model. Because overall demand for avocados from California and Chile will decrease in both time periods, wholesale and producer prices for avocados from California and Chile also will decrease in both time periods. Sixty-two percent of avocado imports from Mexico will enter during Period 1. Since imports from Mexico during Period 1 will comprise a larger share of total avocado consumption, they will exert greater downward pressure than during Period 2 on prices of avocados supplied by California and Chile. In Region B during Period 1, avocados from Mexico will displace 32 percent of the avocados that had been supplied by California. During Period 2, Mexican avocados will displace 19.5 percent and 20.6 percent of California avocados in Regions A and B, respectively.

To better understand the changes in demand, they are decomposed in table 4 into the effects identified at the beginning of this section. There are two general results of the analysis. First, because the price of California avocados will decrease relative to the price of Mexican avocados, there will be a positive substitution effect for California avocados and a negative substitution effect for Mexican avocados. Second, because the aggregate demand for avocados is price inelastic, the expansion effect will be negative for all avocados across all regions and time periods. In calculating the expansion effect, price is held constant at its initial level, and expenditure on avocados is allowed to change. The fall in price is greater than the increase in quantity, due to the inelastic demand, so avocado expenditure declines. Because price is constant, the decline in expenditure is reflected in a lower quantity consumed and a negative expansion effect.

For Region A in Period 1, the consumption of avocados from California and Chile will increase while the consumption of avocados from Mexico will decrease. This shift is mainly due to wholesale price declines for California avocados (11.8 percent) and Chilean avocados (8.8 percent). In this region during Period 2, the varietal effects will outweigh the substitution effects, leading to a decrease in the consumption of California and Chilean avocados when Mexican avocados become available.

In Region B, the varietal effects will be large in both time periods (table 4): In Period 1, an increase of 44.1 million pounds for avocados from Mexico, and decreases of 20.4 million pounds and 16.3 million pounds for avocados from California and Chile; in Period 2, an increase of 37.4 million pounds for avocados from Mexico, and decreases of 24.8 million pounds and 2.8 million pounds for avocados from California and Chile.

Table 2. Summary of Changes in Quantities and Prices<sup>a</sup>

	<u>Initial Prices and Quantities</u>	<u>With Rule</u>	<u>Change</u>	<u>Percentage Change</u>
	Million Pounds			
Quantity				
Total	581.071	633.542	52.471	9.0%
Supplied by:				
California	346.011	320.821	-25.190	-7.3%
Chile	176.814	158.695	-18.119	-10.3%
Mexico	58.247	154.026	95.779	164.4%
	Dollars per Pound			
Wholesale Price of				
Avocados Supplied by:				
California	\$1.63	\$1.43	-\$0.20	-12.3%
Chile	\$1.29	\$1.20	-\$0.09	-6.7%
Producer Price for:				
California	\$1.02	\$0.81	-\$0.21	-20.6%
Chile	\$0.59	\$0.49	-\$0.10	-17.0%

<sup>a</sup>Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

Table 3. Simulation Results

	Initial Prices and Quantities <sup>a</sup>	With Rule <sup>b</sup>	Mean <sup>c</sup>	Std Dev <sup>d</sup>
<u>Quantity Demand</u>	Million Pounds			
Time Period 1 <sup>e</sup>				
<i>Region A</i>				
California	14.115	16.989	17.111	0.656
Chile	12.869	14.525	14.709	0.583
Mexico	58.247	55.198	55.051	0.740
<i>Region B</i>				
California	49.932	34.006	34.141	1.037
Chile	47.102	32.734	33.029	0.803
Mexico	0.000	40.549	40.516	1.430
<i>Region C</i>				
California	51.768	56.992	57.139	1.001
Chile	48.238	49.402	49.759	0.816
Mexico	0.000	0.000	0.000	0.000
Time Period 2 <sup>f</sup>				
<i>Region A</i>				
California	61.490	49.489	49.757	1.306
Chile	18.335	16.050	16.169	0.352
Mexico	0.000	25.236	25.218	1.043
<i>Region B</i>				
California	77.936	61.911	62.252	1.674
Chile	23.207	20.237	20.382	0.432
Mexico	0.000	33.042	33.025	1.423
<i>Region C</i>				
California	90.770	101.434	101.832	1.940
Chile	27.063	25.747	25.913	0.378
Mexico	0.000	0.000	0.000	0.000
California Production	346.011	320.821	322.233	7.379
Imports from Chile	176.814	158.695	159.962	3.283
Imports from Mexico	58.247	154.026	153.810	4.261
<u>Producer Price</u>	Dollars per Pound			
Time Period 1				
California	\$0.871	\$0.697	\$0.692	\$0.034
Chile	\$0.577	\$0.480	\$0.473	\$0.028
Time Period 2				
California	\$1.101	\$0.866	\$0.860	\$0.043
Chile	\$0.599	\$0.511	\$0.503	\$0.035

Table 3. Continued

	Initial Prices and Quantities <sup>a</sup>	With Rule <sup>b</sup>	Mean <sup>c</sup>	Std Dev <sup>d</sup>
<u>Wholesale Price</u>	<u>Dollars per Pound</u>			
Time Period 1 <sup>e</sup>				
<i>Region A</i>				
California	\$1.470	\$1.296	\$1.291	\$0.034
Chile	\$1.103	\$1.006	\$0.999	\$0.028
Mexico	\$1.082			
<i>Region B</i>				
California	\$1.554	\$1.380	\$1.375	\$0.034
Chile	\$1.307	\$1.210	\$1.203	\$0.028
Mexico	\$1.082			
<i>Region C</i>				
California	\$1.471	\$1.297	\$1.292	\$0.034
Chile	\$1.155	\$1.058	\$1.051	\$0.028
Mexico	\$1.082			
Time Period 2 <sup>f</sup>				
<i>Region A</i>				
California	\$1.744	\$1.509	\$1.503	\$0.043
Chile	\$1.461	\$1.372	\$1.365	\$0.035
Mexico	\$1.082			
<i>Region B</i>				
California	\$1.729	\$1.495	\$1.489	\$0.043
Chile	\$1.488	\$1.400	\$1.392	\$0.035
Mexico	\$1.082			
<i>Region C</i>				
California	\$1.686	\$1.452	\$1.446	\$0.043
Chile	\$1.408	\$1.319	\$1.312	\$0.035
Mexico	\$1.082			

<sup>a</sup>Baseline, as shown in appendix 3 table 2.<sup>b</sup>Effects of the rule on quantities and prices (simulation results).<sup>c</sup>Mean values of the sensitivity analysis distributions.<sup>d</sup>Standard deviations of the sensitivity analysis distributions.<sup>e</sup>October 15-April 15.<sup>f</sup>April 16-October 14.

Table 4. Decomposition of the Demand Changes by Demand Region, Supply Region and Time Period

Demand Region/Supply Region	
Time Period 1 <sup>a</sup>	Million Pounds
<i>Region A, California</i>	
Varietal effect	0.000
Substitution effect	3.105
Expansion effect	-0.232
Total	2.873
<i>Region A, Chile</i>	
Varietal effect	0.000
Substitution effect	1.868
Expansion effect	-0.212
Total	1.656
<i>Region A, Mexico</i>	
Varietal effect	0.000
Substitution effect	-2.093
Expansion effect	-0.956
Total	-3.049
<i>Region B, California</i>	
Varietal effect	-20.394
Substitution effect	5.226
Expansion effect	-0.758
Total	-15.926
<i>Region B, Chile</i>	
Varietal effect	-16.334
Substitution effect	2.756
Expansion effect	-0.789
Total	-14.367
<i>Region B, Mexico</i>	
Varietal effect	44.123
Substitution effect	-2.442
Expansion effect	-1.132
Total	40.549

Table 4. Continued

Demand Region/Supply Region	
<u>Time Period 1</u>	Million Pounds
<i>Region C, California</i>	
Varietal effect	0.000
Substitution effect	7.449
Expansion effect	-2.225
Total	5.224
<i>Region C, Chile</i>	
Varietal effect	0.000
Substitution effect	3.237
Expansion effect	-2.073
Total	1.164
<i>Region C, Mexico</i>	
Varietal effect	0.000
Substitution effect	0.000
Expansion effect	0.000
Total	0.000
<u>Time Period 2<sup>b</sup></u>	
<i>Region A, California</i>	
Varietal effect	-18.849
Substitution effect	8.461
Expansion effect	-1.612
Total	-12.000
<i>Region A, Chile</i>	
Varietal effect	-2.179
Substitution effect	0.504
Expansion effect	-0.611
Total	-2.286
<i>Region A, Mexico</i>	
Varietal effect	28.605
Substitution effect	-2.287
Expansion effect	-1.081
Total	25.237

Table 4. Continued

Demand Region/Supply Region	
Time Period 2	Million Pounds
<i>Region B, California</i>	
Varietal effect	-24.788
Substitution effect	10.754
Expansion effect	-1.990
Total	-16.024
<i>Region B, Chile</i>	
Varietal effect	-2.816
Substitution effect	0.610
Expansion effect	-0.764
Total	-2.970
<i>Region B, Mexico</i>	
Varietal effect	37.406
Substitution effect	-2.963
Expansion effect	-1.401
Total	33.042
<i>Region C, California</i>	
Varietal effect	0.000
Substitution effect	15.374
Expansion effect	-4.711
Total	10.663
<i>Region C, Chile</i>	
Varietal effect	0.000
Substitution effect	0.088
Expansion effect	-1.405
Total	-1.317
<i>Region C, Mexico</i>	
Varietal effect	0.000
Substitution effect	0.000
Expansion effect	0.000
Total	0.000

<sup>a</sup>October 15-April 15.<sup>b</sup>April 16-October 14.

## Sensitivity Analysis

A sensitivity analysis was conducted that considers alternative values for the elasticities of substitution and transformation ( $\sigma_1$ ,  $\sigma_2$ , and  $\beta$ ) and California's aggregate supply elasticity ( $\eta_A$ ) in recognition of the uncertainty surrounding the values of these parameters. The approach used to vary them in the sensitivity analysis is described in appendix 4. Because no information is available about their distributions, uniform distributions were assumed, as shown in table 5.<sup>18</sup>

Table 5. Uniform Distributions Used in the Sensitivity Analysis

	Minimum	Mean	Maximum
$\sigma_1^a$	0.50	0.60	0.70
$\sigma_2$	1.65	1.90	2.15
$\beta$	1.00	1.50	2.00
$\eta_A$	0.05	0.35	0.65

<sup>a</sup>The values of  $\sigma_1$  and  $\sigma_2$  depend on the estimated coefficient on the quantity of Californian avocado production in equation (10) in Carman and Craft. The mean value of this coefficient is -0.53. A range of +/- three standard deviations is assumed (for example, +/-0.10 for  $\sigma_1$ ). The price flexibility at the producer level is computed as:

$$flex = \rho * 1.198 * 53.308^{0.23},$$

where  $\rho$  is the value of the estimated coefficient (-0.53 in the base case). Taking the reciprocal of this expression and multiplying by 1.634 yields the own-price demand elasticity at the wholesale level, as explained in section 2. The aggregate demand elasticity for avocados is obtained by multiplying the wholesale level elasticity by 0.595. Once the values of these two elasticities have been obtained, the values of  $\sigma_1$  and  $\sigma_2$  can then be computed as described in appendix 2.

The results of the sensitivity analysis are given in the mean and standard deviation columns in table 3. Relative to the baseline and mean values, the standard deviations are small for all of the reported endogenous variables. The results of the analysis vary little for the given ranges of the parameters shown in table 5.

<sup>18</sup> For a uniform random variable on the interval  $(a, b)$ ,  $\mu = (a + b)/2$  and  $\sigma^2 = (b - a)^2/12$ . In order to assure substitutability in demand, the value of  $\sigma_2$  must exceed the value of  $\sigma_1$ . Thus the range of  $\sigma_2$  utilized in the sensitivity analysis is chosen to always exceed the value of  $\sigma_1$ .

#### 4. Welfare Effects

Removing restrictions on Mexican avocado imports will affect both consumers and producers. For consumers, the concept of equivalent variation is used to quantify these changes. Equivalent variation (EV) refers to the additional amounts of income measured at initial equilibrium prices that would be equal to the price and quantity changes due to the rule. A portion of consumer gains may be captured by retailers exerting market power in setting avocado retail prices. To the extent that this occurs, overall welfare gains are slightly overstated and there is a small deadweight loss.

The EV for each demand region and time period is determined, as described in appendix 5, and the results are presented in table 6. Under the rule, the decrease in California avocado prices due to producers' inelastic supply response (0.35) will result in large gains in consumer utility. EV across all regions and time periods will total \$121.7 million. Not surprisingly, consumers in Region A in Period 1 will gain the least, since this is the region and time period already approved to receive avocados from Mexico. Consumer gains in Region B will be greater than in Region C in both time periods, since Mexican avocados will be restricted from entering Region C for two years.

The welfare impacts for avocado producers in California and Chile are determined by computing the change in producer surplus based on their avocado factor endowment supply curves.<sup>19</sup> As shown in figure 4, a decrease in the producer price index will decrease the amount of factor endowment employed in avocado production. The reduction in producer surplus is given by the sum of the areas in rectangle A and triangle B.

Given the decline in producer prices, California avocado producers will experience welfare losses equivalent to \$71.4 million. Chile's suppliers will lose producer surplus equivalent to \$15.7 million. The net change in U.S. welfare is computed by subtracting the loss in producer surplus for California producers from the total EV. As shown in table 6, the net welfare gain will be \$50.3 million.

The mean and standard deviation columns in table 6 show the results of a sensitivity analysis of the welfare changes. As with the sensitivity analysis of the quantity and price changes in table 3, the standard deviations for the EV values are small. The standard deviations for the changes in producer surplus are larger, implying greater variability. This greater variability is largely attributable to the wide distribution assumed for California's aggregate supply elasticity in the sensitivity analysis; there is greater uncertainty with respect to the supply elasticity as compared to the demand-based elasticities of substitution. If the change in producer surplus for Californian avocado producers is normally distributed, the 95 percent confidence interval for their loss in producer surplus would be (\$45.1 million, \$102.2 million).

---

<sup>19</sup> The supply of the avocado endowment factor is used because it determines the overall level of avocado production in a given region. Also, by definition, producer surplus is based on the concept of a specific factor of production.

Table 6. Welfare Gains and Losses

	Welfare Effect <sup>a</sup>	Mean <sup>b</sup>	Std Dev <sup>c</sup>
	Million Dollars		
Changes in Producer Surplus			
California	-\$71.37	-\$73.66	\$14.27
Chile	-\$15.71	-\$17.04	\$5.29
Equivalent Variation			
Period 1 <sup>d</sup>			
Region A	\$4.02	\$4.23	\$0.99
Region B	\$21.92	\$22.39	\$2.08
Region C	\$14.17	\$14.85	\$3.34
Period 2 <sup>e</sup>			
Region A	\$24.98	\$25.47	\$2.70
Region B	\$31.76	\$32.38	\$3.38
Region C	\$24.81	\$25.71	\$5.29
Net U.S. Welfare Change	\$50.29	\$51.37	\$3.61

<sup>a</sup>The difference between baseline values and values with the rule.

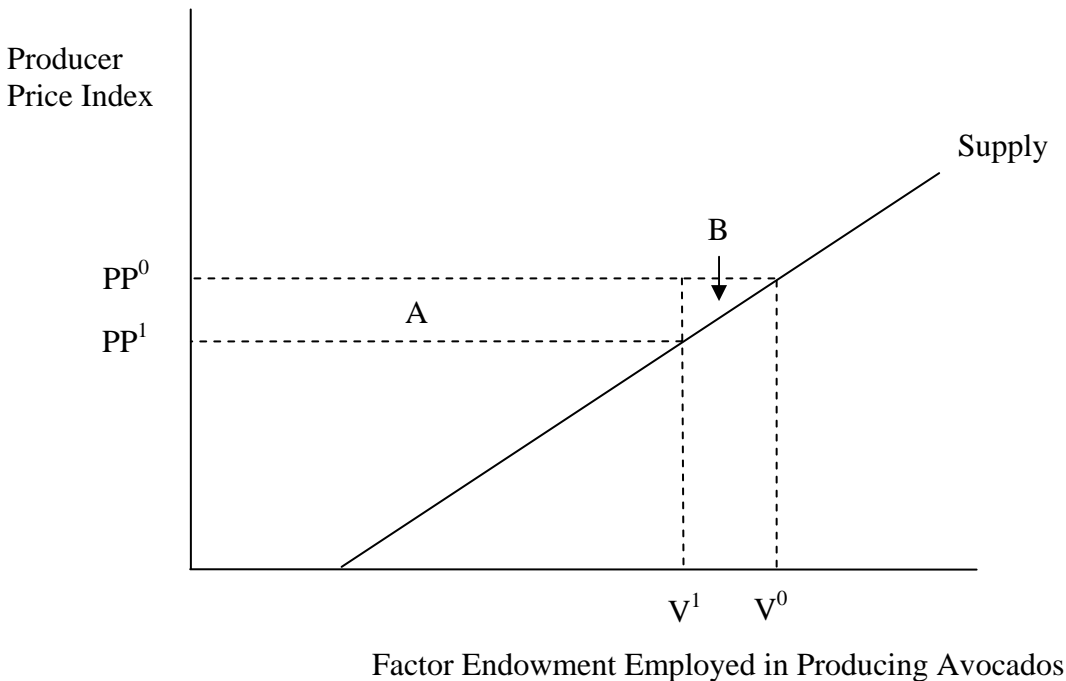
<sup>b</sup>Mean values of the sensitivity analysis distributions.

<sup>c</sup>Standard deviations of the sensitivity analysis distributions.

<sup>d</sup>October 15-April 15.

<sup>e</sup>April 16-October 14.

Figure 4. Producer Surplus Loss from a Price Decrease for Avocado Producers in California and Chile



## 5. Alternatives

One alternative to the rule would be to leave the regulations unchanged. In this case, access of Mexican avocados would continue to be restricted to the 31 States and the District of Columbia currently approved to receive avocados from Mexico between October 15 and April 15 (and Alaska year-round). The simulated impacts for U.S. producers and consumers would not occur.

With no rule change, demand for avocados from all three supply regions would continue to increase due to population and income growth, with the relative percentages supplied by California, Florida, and Mexico shifting in response to changes in relative prices and preferences. It is noted that Mexico's avocado exports to the United States have been expanding rapidly (27.9 million pounds in 2001, 58.8 million pounds in 2002, 76.8 million pounds in 2003), as it acquires a larger share of the market in the approved States between October 15 and April 15. During the baseline period (October 15, 2001 to October 15, 2003), more than 68 percent of avocado sales in this region and time period were supplied by Mexico, an increase of nearly 11 percent from its market share between October 15, 2000 and October 15, 2002.

Another alternative to the rule would be to allow access of Mexican avocados to all States year-round without the two-year delay for California, Florida, and Hawaii. This alternative would result in a larger increase in the quantity of avocados imported and larger price and quantity impacts for California avocado producers. California producers' welfare losses, welfare gains for U.S. consumers, and net welfare benefits for the United States would all be larger. We describe here effects of year-round access of Mexican avocados to all States with no delays, using the October 15, 2001 – October 15, 2003 baseline.

Quantity and price changes of allowing Mexican avocados to enter all States throughout the year with no delays are shown in table 7. Under this alternative, avocado consumption would increase by 13.7 percent (compared to 9.0 percent under the rule). Quantities supplied by California and Chile would decline by 12.2 and 16.5 percent, respectively (compared to 7.3 and 10.3 percent), while imports from Mexico would increase to 209 million pounds (compared to 154 million pounds), 3.6 times their initial level. California's prices would fall by 20.9 percent at the wholesale level (compared to 12.3 percent) and by 34.3 percent at the producer level (compared to 20.6 percent). Thus, all impacts would be larger in comparison to expected effects of the rule.

Table 7. Alternative of Allowing Avocados from Mexico to be Imported Year-round into All States without the Two-Year Delay for California, Florida, and Hawaii: Summary of Changes in Quantities and Prices<sup>a</sup>

	<u>Initial Prices and Quantities</u>	<u>With Alternative</u>	<u>Change</u>	<u>Percentage Change</u>
	<u>Million Pounds</u>			
Quantity				
Total	581.071	660.868	79.797	13.7%
Supplied by:				
California	346.011	303.866	-42.145	-12.2%
Chile	176.814	147.695	-29.119	-16.5%
Mexico	58.247	209.307	151.060	259.3%
	<u>Dollars per Pound</u>			
Wholesale Price of				
Avocados Supplied by:				
California	\$1.63	\$1.29	-\$0.34	-20.9%
Chile	\$1.29	\$1.15	-\$0.14	-10.9%
Producer Price for:				
California	\$1.02	\$0.67	-\$0.35	-34.3%
Chile	\$0.59	\$0.44	-\$0.15	-25.4%

<sup>a</sup>Prices weighted by regional and time period quantities. Producer and wholesale prices for avocados from Mexico are assumed constant in the model.

Welfare effects for this alternative are shown in table 8. Total equivalent variation across all regions and time periods would be \$184.5 million, compared to \$121.7 million with the rule. California avocado producers would experience welfare losses of \$114.4 million (compared to \$71.4 million). The net gain in welfare for the United States would be \$70.1 million (compared to \$50.3 million).

As with the sensitivity analysis of impacts of the rule, a sensitivity analysis for this alternative indicates small standard deviations for the EV values and larger ones for the changes in producer surplus. If the change in producer surplus for Californian avocado producers is normally distributed, the 95 percent confidence interval for their loss in producer surplus would be (\$75.8 million, \$157.7 million).

Although the no-delay alternative is preferable in terms of net benefits of the action, the rule including the two-year delay of entry of Mexican avocados into California, Florida, and Hawaii has been chosen by USDA because it will provide an opportunity for the efficacy of the rule's risk-mitigating safeguards to be demonstrated through year-round distribution to the remaining 47 States.

Table 8. Alternative of Allowing Avocados from Mexico to be Imported Year-round into All States without the Two-Year Delay for California, Florida, and Hawaii: Welfare Gains and Losses

	Welfare Effect <sup>a</sup>	Mean <sup>b</sup>	Std Dev <sup>c</sup>
	Million Dollars		
Changes in Producer Surplus			
California	-\$114.39	-\$116.72	\$20.48
Chile	-\$24.35	-\$24.40	\$5.79
Equivalent Variation			
Period 1 <sup>d</sup>			
<i>Region A</i>	\$7.84	\$7.86	\$1.18
<i>Region B</i>	\$29.66	\$29.68	\$2.34
<i>Region C</i>	\$27.33	\$27.32	\$2.48
Period 2 <sup>e</sup>			
<i>Region A</i>	\$32.42	\$32.90	\$4.22
<i>Region B</i>	\$41.08	\$41.68	\$5.29
<i>Region C</i>	\$46.12	\$46.83	\$6.34
Net U.S. Welfare Change	\$70.05	\$69.54	\$1.93

<sup>a</sup>The difference between baseline values and values with this alternative.

<sup>b</sup>Mean values of the sensitivity analysis distributions.

<sup>c</sup>Standard deviations of the sensitivity analysis distributions.

<sup>d</sup>October 15-April 15.

<sup>e</sup>April 16-October 14.

## 6. Final Regulatory Flexibility Analysis

The Regulatory Flexibility Act of 1980 (Public Law 96-354) requires agencies to evaluate the potential effects of their proposed and final rules on small businesses, small organizations and small governmental jurisdictions.<sup>20</sup>

Section 603 of the Act requires agencies to prepare and make available for public comment a final regulatory flexibility analysis (FRFA) describing the impact of final rules on small entities. Section 603(b) of the Act specifies the content of a FRFA. Each FRFA must contain:

- A description of the reasons why action by the agency is being considered;
- A succinct statement of the objectives of, and legal basis for, the final rule;
- A description of and, where feasible, an estimate of the number of small entities to which the final rule will apply;
- A description of the projected reporting, record keeping and other compliance requirements of the final rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record;
- An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the final rule;
- Each final regulatory flexibility analysis shall also contain a description of all significant alternatives to the final rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the final rule on small entities.

In this section, we address each of these FRFA requirements. The section concludes with responses to comments received on the proposed rule regarding small-entity issues.

### 1. A description of the reasons why action by the agency is being considered

The rule is in response to a request from the Government of Mexico for increased access of Hass avocados from Mexico into the United States. Under section 412(a) of the Plant Protection Act, the Secretary of Agriculture may prohibit or restrict the importation and entry of any plant or plant product if the Secretary determines that the prohibition or restriction is necessary to prevent the introduction in the United States or the dissemination within the United States of a plant pest or noxious weed. The Secretary has determined that it is not necessary to prohibit the importation of Hass avocados from Mexico subject to phytosanitary requirements described in this rule in order to prevent the introduction into the United States or the dissemination within the United States of a plant pest or noxious weed.

---

<sup>20</sup> This section follows the example provided by Small Business Administration, Office of Advocacy, "A Guide for Government Agencies: How to Comply with the Regulatory Flexibility Act," May 2003, pp.53-58 (Example of a Final Regulatory Flexibility Analysis).

2. A succinct statement of the objectives of, and legal basis for, the final rule

The rule will permit Hass avocados from Mexico to be imported into all States year-round, with their entry into California, Florida, and Hawaii delayed for two years. The imported Hass avocados will be required to be grown in approved orchards in approved municipalities in Michoacán, Mexico, and satisfy certain phytosanitary conditions. The rule will facilitate commerce between the United States and Mexico and result in net benefits to the United States. The legal basis for the rule can be found in the Code of Federal Regulations under "Subpart—Fruits and Vegetables" (7 CFR 319.56--2ff).

3. A description of and, where feasible, an estimate of the number of small entities to which the final rule will apply

U.S. businesses that will be directly affected by the rule are Hass avocado producers, handlers and importers. We find that a substantial number of businesses in all three affected groups are small entities.

*Hass Avocado Producers.* As described in the Introduction, nearly all U.S. production of Hass avocados takes place in California, where Hass is the dominant variety grown. In the analysis for the proposed rule, we used information from the 1997 Census of Agriculture to evaluate the size distribution of California avocado farms. The 1997 Census grouped avocado farms by the number of acres harvested. Average farm income was determined for each size category using an average producer price (table 9).

We observe in the last column of table 9 the wide range in average receipts for farms of different size. An avocado farm is considered small if it has annual receipts of not more than \$750,000.<sup>21</sup> By this definition, the 98 percent of California avocado farms with less than 100 acres in 1997 would have qualified as small entities.

The 2002 Census of Agriculture is now available. Unfortunately, information on the quantity of avocados harvested by farms of different size—data that would have allowed us to update average receipts by size of farm—is not reported in the 2002 Census.<sup>22</sup> We assume the difference in average receipts between avocado farms with less than 100 acres harvested and ones with 100 or more acres harvested was similar in 2002 to that in 1997, and that all farms with less than 100 acres harvested in 2002 were small entities. These small entities numbered 4,687 out of 4,801 farms in 2002, or over 97 percent (table 10). We conclude that a substantial number of Hass avocado producers that will be affected by the rule are small entities.<sup>23</sup>

The expected impact of the rule for these small-entity producers is described in terms of the decrease in gross revenue, as derived from the results of the general analysis in section 3. The

---

<sup>21</sup> NAICS code 111339, Other Non-citrus Fruit Farming. All small-entity definitions in this analysis are provided in Title 13 of the Code of Federal Regulations, Part 121: Small Business Size Regulations.

<sup>22</sup> This information was not collected for a number of specialty crops (Jorge Garcia-Pratts, NASS, personal communication).

<sup>23</sup> The Census of Agriculture data include producers of all varieties of avocados. We assume Hass avocado production is distributed proportionately among the various farm sizes.

model indicates that there will be a 26.7 percent decline in gross revenue, assuming the decrease is proportionally spread across all farms (table 11). The gross revenue declines are attributable more to decreases in price than to decreases in quantity (table 12).

Table 9. California Avocado Farms and Sales, Categorized by Number of Acres Harvested, 1997

1997							
Acres Harvested	Farms	Pounds Harvested	Crop Value	Percent of Farms	Cumulative Percentage	Average Number of Pounds Harvested per Farm	Average Receipts from Sales per Farm
0.1 to 0.9	579	634,676	\$568,683	11.5%	11.5%	1,096	\$982
1.0 to 4.9	2,291	14,698,903	\$13,170,516	45.5%	57.0%	6,416	\$5,749
5.0 to 14.9	1,224	41,043,490	\$36,775,802	24.3%	81.3%	33,532	\$30,046
15.0 to 24.9	421	37,444,332	\$33,550,884	8.4%	89.7%	88,941	\$79,693
25.0 to 49.9	298	50,530,849	\$45,276,669	5.9%	95.6%	169,567	\$151,935
50.0 to 99.9	127	43,532,067	\$39,005,618	2.5%	98.1%	342,772	\$307,131
100 or more	96	110,646,247	\$99,141,289	1.9%	100.0%	1,152,565	\$1,032,722

Sources: USDA NASS, 1997 Census of Agriculture, Volume 1, Part 5, Chapter 1, Table 43. Value of production based on California Avocado Commission data: 89.602 cents per pound.

Table 10. Comparison of the Number and Acreage of California Avocado Farms, by Farm Size, 2002 and 1997

Size of Farm	Number of Farms				Acreage			
	2002	1997 (Revised)	Change	Percentage Change	2002	1997 (Revised)	Change	Percentage Change
0.1 to 0.9 acres	529	754	-225	-29.8%	236	361	-125	-34.6%
1.0 to 4.9 acres	2,115	2,801	-686	-24.5%	4,655	6,227	-1,572	-25.2%
5.0 to 14.9 acres	1,172	1,388	-216	-15.6%	9,516	11,353	-1,837	-16.2%
15.0 to 24.9 acres	425	457	-32	-7.0%	8,034	8,470	-436	-5.1%
25.0 to 49.9 acres	316	330	-14	-4.2%	10,530	11,393	-863	-7.6%
50.0 to 99.9 acres	130	134	-4	-3.0%	9,060	9,208	-148	-1.6%
100 acres or more	114	99	15	15.2%	25,524	27,979	-2,455	-8.8%
Total	4,801	5,963	-1,162	-19.5%	67,555	74,991	-7,436	-9.9%

Source: USDA NASS, 2002 Census of Agriculture, Volume 1, Chapter 1, California State Level Data, Table 36.

Table 11. Annual Impact on Gross Revenue for California Hass Avocado Producers

Initial gross revenue (Baseline) <sup>a</sup>	\$354.32 million
Gross revenue with the rule <sup>a</sup>	\$259.58 million
Decrease in gross revenue incurred by large and small Hass avocado producers	\$94.74 million
Decrease incurred by small-entity avocado producers <sup>b</sup>	\$59.69 million
Decrease as a percentage of initial gross revenue <sup>c</sup>	26.7%

<sup>a</sup>Gross revenue values are based on the producer prices and demand quantities for avocados supplied by California, shown in table 3.

<sup>b</sup>Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested in 1997. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.

<sup>c</sup>The decrease in gross revenue is assumed to be proportionally spread across all producers.

Table 12. Percentage Changes in California Avocado Producer Prices and in Quantities of Avocados Supplied by California

	<u>Price</u>	<u>Quantity</u>
Period 1	-20.0%	-6.8%
Period 2	-21.3%	-16.0%

*Handlers.* California Hass avocado handlers (firms engaged in post-harvest activities) will be directly affected by the rule. Included in comments received on the analysis for the proposed rule is the following information on the number and size of handlers that may be affected, provided by the California Avocado Commission:

To assist the Department with this analysis, the Commission reviewed its records of assessments paid by domestic avocado handlers for the period from November 1, 2002 through October 31, 2003. All proprietary information reported to the Commission by California avocado handlers is confidential and disclosure is unauthorized except when required in a judicial proceeding (California Food and Agricultural Code § 67104). However, the Commission is able to provide the Department with compiled information such as the number of California avocado handlers and a range of relative values for the

volume of fruit handled during the stated period. Commission records indicate that 51 companies were active handlers of California avocados during the aforementioned reporting period. Of this number, 18 companies had first sales of avocados of under \$10,000; 8 companies had avocado sales of between \$10,000 and \$49,999; 5 companies had sales from \$50,000 to \$99,999; 5 companies had sales from \$100,000 to \$499,999; 2 companies had sales from \$500,000 to \$999,999; 2 companies had sales from \$1 million to \$4,999,999; 1 company had sales from \$5 million to \$9,999,999; 2 companies had sales from \$10 million to \$19,999,999; 6 companies had sales from \$20,000,000 to \$49,999,999; and 2 companies sold over \$50 million worth of California avocados.

Companies handling avocados are considered small businesses if their annual receipts are not more than \$5 million.<sup>24</sup> By this definition, the information above indicates that 40 of the 51 firms are small entities. We conclude that a substantial number of the handlers that will be affected by the rule are small entities.

The decrease in producers' revenues will mean a decrease in receipts by small-entity handlers as well. Negative impacts may be at least partially alleviated by additional avocado business activities in Mexico in which U.S. handlers may be involved, but it is unlikely that the smaller firms will have this opportunity. Decreased receipts from reduced avocado sales may also be moderated if the firms are engaged in handling produce other than avocados. If losses in revenue for handlers is similar to that estimated for Hass avocado producers, then a substantial number will be significantly affected by the rule.

*Importers.* As with California avocado handlers, the California Avocado Commission was able to provide APHIS with information on the number and size of the companies that import Hass avocados:

According to Hass Avocado Board records ... there were 85 importers of fresh Hass avocados during the period from July 1, 2003 to June 30, 2004. Of this number, it is estimated that 7 companies imported fresh Hass avocados with a first wholesale value of under \$10,000; 9 companies imported Hass avocados valued between \$10,000 and \$49,999; 6 companies imported Hass avocados valued from \$50,000 to \$99,999; 21 companies imported Hass avocados valued from \$100,000 to \$499,999; 9 companies imported Hass avocados valued from \$500,000 to \$999,999; 17 companies imported Hass avocados valued from \$1 million to \$4,999,999; 3 companies imported Hass avocados valued from \$5 million to \$9,999,999; 5 companies imported Hass avocados valued from \$10 million to \$19,999,999; and 4 companies imported fresh Hass avocados with a first wholesale value of over \$20 million. Import values for the remaining 4 companies during this period are not known.

---

<sup>24</sup>North American Industry Classification System (NAICS) code 115114, Postharvest Crop Activities (except Cotton Ginning).

Firms that import avocados are defined as small entities if they have 100 or fewer employees.<sup>25</sup> From the above distribution, the annual wholesale value of Hass avocados imported by 52 of the 85 firms is less than \$1 million. We believe these firms are likely to employ fewer than 100 employees, and therefore a substantial number of importers affected by the rule will be small entities. As a group, these firms will benefit from the increase in imports of Hass avocados from Mexico (an increase of nearly 96 million pounds), but gains will be tempered by reduced imports from Chile (a reduction of about 18 million pounds).

4. A description of the projected reporting, record keeping and other compliance requirements of the final rule including an estimate of the classes of small entities which will be subject to the requirement and the type of professional skills necessary for preparation of the report or record

The rule contains no new information collection or record keeping requirements under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*). The final rule will discuss the Paperwork Reduction Act burden figures. A point of contact for detailed information collection activities will be identified in the final rule.

5. An identification, to the extent practicable, of all relevant Federal rules which may duplicate, overlap or conflict with the final rule

We know of no relevant Federal rules which may duplicate, overlap, or conflict with the final rule.

6. Each final regulatory flexibility analysis shall also contain a description of all significant alternatives to the final rule which accomplish the stated objectives of applicable statutes and which minimize any significant economic impact of the final rule on small entities

Alternatives to the rule, presented in section 5, would be either (i) to not change the current regulations or (ii) to proceed with allowing Mexican Hass avocados to be imported into all States year-round without the two-year delay for California, Florida, and Hawaii. The status quo alternative would be preferable for California's avocado producers, but it would not yield the net benefits to the United States shown to be gained by expanding U.S. access for Mexican Hass avocados.

The rule is preferable to the no-delay alternative for California producers. The analysis shows prices for California producers falling by 21 cents per pound and California Hass avocado production decreasing by 25 million pounds under the rule, compared to declines of 35 cents per pound and 42 million pounds if there are no delays (tables 2 and 7). Producer surplus losses—declines in revenue beyond variable costs—are estimated with the rule to be about \$71 million, compared to losses of about \$114 million without the two-year delay (tables 6 and 8). In all respects, California producers will be harmed less when there is a two-year delay for California, Florida, and Hawaii.

---

<sup>25</sup>NAICS code 442480, Fresh Fruit and Vegetable Wholesalers. The wholesale sector comprises two types of wholesalers: those that sell goods on their own account and those that arrange sales and purchases for others for a commission or fee. Importers are included in both cases.

The expected impact for California's small-entity avocado producers under the no-delay alternative, in terms of reduced gross revenue, is shown in table 13. The decline would be 42.2 percent, compared to a decline of 26.7 percent with the rule. Gross revenue declines under the alternative, even more so than with the rule, are mainly attributable to price declines (table 14).

Table 13. Alternative of Allowing Avocados from Mexico to be Imported Year-round into All States without the Two-Year Delay for California, Florida, and Hawaii: Annual Impact on Gross Revenue for California Avocado Producers

Initial gross revenue (Baseline)	\$354.32 million
Gross revenue under the alternative	\$204.73 million
Decrease in gross revenue incurred by large and small Hass avocado producers	\$149.59 million
Decrease incurred by small-entity avocado producers <sup>a</sup>	\$94.24 million
Decrease as a percentage of initial gross revenue <sup>b</sup>	42.2%

<sup>a</sup>Decreases in gross revenue are multiplied by 63 percent, the percentage of the total value produced by farms with less than 100 acres harvested in 1997. Hass avocado production is assumed to be proportionally distributed among farms of all sizes.

<sup>b</sup>The decrease in gross revenue is assumed to be proportionally spread across all producers.

Table 14. Alternative of Allowing Avocados from Mexico to be Imported Year-round into All States without the Two-Year Delay for California, Florida, and Hawaii: Percentage Changes in California Avocado Producer Prices and in Quantities of Avocados Supplied by California

	<u>Price</u>	<u>Quantity</u>
Period 1	-37.3%	-14.0%
Period 2	-33.2%	-19.4%

In sum, reductions in price, quantity, and producer surplus for California producers would be greater under the no-delay alternative than with the rule. Larger losses for producers would also mean larger losses for California's small-entity Hass avocado handlers. Both producers and handlers will benefit from the two-year delay. For small-entity Hass avocado importers, the no-delay alternative would be preferable, since it would mean a larger increase in imports (taking

into account reduced quantities from Chile): 121.9 million pounds compared to 77.7 million pounds with the rule. In either case, importers will benefit compared to leaving the regulations unchanged.

#### Small-Entity Issues Raised by Commenters on the Analysis for the Proposed Rule

*Issue:* In its analysis, APHIS mentions that California, Florida and Hawaii produce avocados. However, the analysis included in the proposed rule only discusses the impact on California producers. While it is clear that Hawaii produces avocados for intrastate consumption, there should be some discussion of the impact of the rule on Florida producers. For example, the rule should identify the number of producers in Florida and estimate how many are small and thus, will be impacted by the rule.

*Response:* Production of Hass avocados in Florida and Hawaii is negligible, and therefore producers in those States will not be directly affected by the rule. The green-skin avocado varieties grown in Florida and Hawaii and Hass avocados grown in California are weak substitutes for one another and should not be compared, as evidenced by the large difference in their prices. The 2003-2004 average prices per ton were \$2,170 for California avocados (where the Hass variety is dominant), \$1,240 for Hawaii avocados, and \$808 for Florida avocados.<sup>26</sup> In the model, green-skin avocado varieties are included with other goods that compete with Hass avocados for the consumer's dollar. Whatever indirect impacts the rule may have on small-entity avocado producers in Florida and Hawaii are expected to be small, all the more so given the two-year delay of entry of Mexican Hass avocados into those States.

*Issue:* APHIS documented the impacts as a percentage of revenue lost in California, but it doesn't go the next extra step to examine how that might impact growers. The agency should determine profit margins for growers and examine how the impact will affect their bottom line, perhaps by using average industry profit margins for appropriately sized agricultural firms. This could reveal a potentially important impact caused by one parameter in the model. Specifically, very inelastic supply of avocados by California producers means that while prices fall dramatically, California growers don't reduce production much. Thus, California producer costs do not decrease nearly as much as their revenues, which drop over 30 percent. This undoubtedly will strain profit margins and suggests that there potentially could be significant business closures among growers—particularly among very small growers—who may exit the market. APHIS should consider completing a profitability analysis that will assess the possibility of business closures. Ideally, the model should also include a more long run market analysis that will allow entry and exit of producers. It seems likely that with the possibility of exit, and the relatively elastic supply of Mexican avocados, the losses to California growers will be greater in the long run than in the short run.

*Response:* California producers will be economically harmed by the rule, but not as severely as they would be if there were no delayed access of Mexican Hass avocados into California, Florida, and Hawaii. The question of effects of the rule on small-entity profit margins is not easily addressed. Each avocado farm draws upon a unique set of human and capital resources and marketing arrangements that define its financial position and prospects. Profit margins vary among firms and from one season to the next. Nonetheless, the Agency agrees with the

---

<sup>26</sup> USDA NASS, "Noncitrus Fruits and Nuts 2003 Summary," July 2004.

commenter that small-entity producers with recent histories of small or negative profit margins may be placed at risk by the rule.

As an indicator of possible effects, we reproduce in table 15 part of the results of a profitability analysis published in 2002. The table shows returns to management (returns per acre above cash and non-cash costs) for various price-yield combinations. For example, for a yield of 5,000 pounds per acre, a drop in price from \$1.10 to \$1.00 per pound would mean returns to management declining from \$276 per acre to a negative \$224 per acre.

The profitability analysis was based on avocado orchard establishment and production practices considered typical in Ventura and Santa Barbara Counties. The results are applicable to the economic analysis to the extent that costs and returns in Ventura and Santa Barbara Counties in 2001 are similar to those for California Hass avocado producers generally between October 2001 and October 2003. With the rule, California producer prices are shown to fall from \$1.02 to \$0.81 per pound (table 2). Using the price-yield combinations from table 15, farms with yields of at least 7,000 pounds per acre would still show positive returns to management (although total returns would be reduced due to the 7.3 percent decline in California's overall supply indicated by the model). Farms with yields of 6,000 pounds per acre would move from positive to negative returns to management. Farms with yields of 5,000 pounds per acre or less would probably not be providing positive returns to management to begin with, given the initial baseline price of \$1.02 per pound. The 2003-04 estimated average yield for Hass avocado orchards in California is 6,865 pounds per acre.<sup>27</sup>

The rule may contribute to some small-entity avocado farms failing, if their operation is already showing borderline returns. We note that the California avocado industry has been trending toward fewer operations, with expansion only among the very largest producers. Overall, the number of avocado farms in California dropped by nearly 20 percent between 1997 and 2002, from 5,963 to 4,801 farms (table 10).<sup>28</sup> There was a decrease in the number for farms of all sizes except those with 100 or more acres (which increased in number from 99 in 1997 to 114 in 2002), and the smaller farms experienced the larger percentage declines. Even without this rule, avocados farms are becoming fewer, with the sharpest decline for those of smallest size.

The census data also show a decline in California's avocado acreage. Acres harvested fell by 10 percent between 1997 and 2002. Declines were experienced by farms of all sizes, with the largest percentage declines borne by the smaller farms. In sum, reductions in California avocado acreage and in the number of small avocado farms are prevailing trends. Revenue declines because of the rule are expected to be large compared to losses that small-entity producers may have experienced because of the industry's contraction and growing concentration. California producers will be economically harmed by the rule, but we cannot predict that a certain number of firms may fail.

---

<sup>27</sup> California Avocado Commission, [http://www.avocado.org/growers/pages/2000\\_38.php?sd=growers](http://www.avocado.org/growers/pages/2000_38.php?sd=growers).

<sup>28</sup> This decline in the number of avocado farms is on top of a 16-percent decline between 1992 and 1997.

Table 15. Returns to Management per Acre for Various Yields and Prices, Ventura and Santa Barbara Counties, 2001.

	<u>Yield in Pounds per Acre</u>								
	3,000	4,000	5,000	6,000	7,000	7,500	8,000	9,000	10,000
\$/Pound	Dollars per Acre								
0.70	-2,871	-2,298	-1,724	-1,151	-557	-290	-4	570	1,143
0.80	-2,571	-1,898	-1,224	-551	123	460	796	1,470	2,143
0.90	-2,271	-1,498	-724	49	823	1,210	1,596	2,370	3,143
1.00	-1,971	-1,098	-224	649	1,523	1,960	2,396	3,270	4,143
1.10	-1,691	-698	276	1,249	2,223	2,710	3,196	4,170	5,143
1.20	-1,371	-298	776	1,849	2,923	3,460	3,996	5,070	6,143
1.30	-1,071	102	1,276	2,449	3,623	4,210	4,796	5,970	7,143

Source: Table 7 of "Avocado Sample Establishment and Production Costs and Profitability Analysis for Ventura and Santa Barbara Counties, Based on 2001 Data Collected in Ventura and Santa Barbara Counties, California," by Etaferahu Takele, Ben Faber, and Silvana Chambers, UCCE Southern California.

*Issue:* In addition, APHIS should analyze the potential impact to the very small growers with less than five-acre plots, and potentially those in the next higher size category as well. As it stands, the analysis for the proposed rule mentions only that it is likely these growers produce other agricultural products in addition to avocados because of the small revenue earned from avocado production. To analyze profitability and business survival, a proper baseline of revenues for these producers would need to be established, including revenues from all production, so that the losses from diminished avocado revenues could be properly analyzed. One way to accomplish this might be to assume that these growers would earn revenues equivalent to the average small farm in California.

*Response:* In the analysis for the proposed rule, we took note of the large number of very small avocado farms. The 1997 Census of Agriculture data showed over one-half of the avocado farms that year harvested less than five acres. Average 1997 receipts for these farms was about \$4,800.<sup>29</sup> We concluded that farms of less than five acres could not be the principal source of income for their owners.

<sup>29</sup> From table 9:  $(\$568,683 + \$13,170,516)/(579 + 2,291) = \$4,787$ .

We did not intend to imply that these smaller avocado producers grow other crops, but only that their average annual revenue from avocado production would necessitate other sources of income. We agree that to properly analyze impacts of the rule for small entities, we would need to have data on these other revenue sources, but this information is not available. If all revenue sources for small-entity avocado producers could be obtained, it would likely indicate a wide range of income from a variety of sources. We have no basis for assuming that agricultural receipts for California's small-entity avocado growers are on average equivalent to revenues earned by other small-entity farmers in that State.

## 7. Longer-term Effects

This analysis describes near-term impacts of two alternatives to current regulations restricting the importation of avocados from Mexico: the rule, which will allow the avocados to enter all States year-round except California, Florida, and Hawaii, for which entry would be delayed two years; and an alternative to the rule, which would allow importation into all States year-round with no delay for any States. The near term may be thought to represent the first year that the rule is in effect. We address here the question of how the alternatives compare in the longer term.

A static, partial equilibrium model is used to depict expected effects of the regulatory change. An initial market equilibrium for avocados was determined based on baseline quantities and prices. Regulatory expansion of access of Mexican avocados into the U.S. market can be thought of as an exogenous shock. The resulting increase in avocado imports from Mexico will lead, in general, to a decline in the prices and quantities of avocados supplied by California and Chile. A new partial equilibrium is attained through regional price and quantity changes, given the parameters of the model.

Whether the effects described in the analysis would be fully realized in the first year of the rule is not known. While the sale of Mexican avocados year-round and the addition of 15 States with the rule (or 18 States under the alternative) will have immediate effects, impacts in the first 12 months may or may not match those described by the model. Changes in buyers' perceptions and preferences—the non-price influences represented by the model's shift parameters—will occur over a period of time. The model does not inform as to how long this transition will take.

If we assume that the effects described in this analysis do occur in the first year, and we assume that the changed supply and demand conditions continue into the second year, then by the end of the second year the effects would be twice those reported in the analysis. When compared to the baseline, the net welfare gain attributable to the rule would be about \$50 million in Year 2, the same as in Year 1, for an undiscounted net gain of about \$100 million over the two years. (The preferred comparison would be one of conditions with and without the rule in Year 2, but the model describes neither of these situations.)

More realistically, by the second year there will be production and marketing responses by California producers to the substantial increase in avocado imports from Mexico. Altered regional marketing strategies and industry promotional activities, for instance, may influence the effects for California producers from Year 1 to Year 2 of the rule (or of the alternative). We do not believe that the new equilibrium described by the model, assumed to be attained in Year 1, will remain unchanged in Year 2.

In Year 3 and afterwards, as long as there are not any pest discoveries that prevent expansion of Mexican avocado imports into California, Florida, and Hawaii, the rule and the alternative are the same. Changes in Year 3 of the rule can be expected to be broadly similar to differences in impact between the rule and the alternative described by the model for Year 1. There will be a further decrease in producer welfare and increase in consumer welfare, with the latter outweighing the former for an overall net increase in U.S. welfare.

We would not expect the changes in Year 3 to be equal to the differences in impact between the rule and the alternative described for Year 1. Inclusion of California, Florida, and Hawaii will take place two years after the year-round and 15-State expansions have occurred. Two years of Mexican avocado imports into southern and western States may result in regional prices and quantities different from those portrayed by the model. The Year 1 difference between the rule and the alternative in net welfare gains is estimated to be about \$20 million, but the undiscounted net welfare gain in Year 3 of the rule will probably have a different value.

The analysis shows near-term impacts of the rule and the alternative. The period is assumed to represent the first year that the rule is in effect. Differences in impact between the rule and the alternative will continue during Year 2, but are unlikely to be the same as modeled for the first year. The third-year adjustment, when the rule will allow Mexican avocado imports into all States, will remove all distinctions between the rule and the alternative. Effects in Year 3 will be like those indicated by the Year 1 differences in impact between the rule and the alternative, but the quantity, price, and welfare changes are likely to differ from those described by the model for Year 1.

## References

- Arndt, C. and T.W. Hertel, "Revisiting 'The fallacy of free trade'," *Review of International Economics*, 5(2) (May 1997): 221-229.
- Carman, H.F. and R.K. Craft. "An Economic Evaluation of California Avocado Industry Marketing Programs, 1961-1995." Giannini Foundation Research Report Number 345, California Agricultural Experiment Station, July 1998.
- Keller, W.J. *Tax Incidence: A General Equilibrium Approach*. New York, N.Y: Elsevier North-Holland, 1980.
- Romano, Eduardo. *Two Essays on Sanitary and Phytosanitary Barriers Affecting Agricultural Trade Between Mexico and the United States*, Ph.D. Dissertation, Virginia Polytechnic Institute and State University, April 1998.
- Stroud, A.H. "Remarks on the disposition of points in numerical integration formulas," *Math. Tables Aids Computing*, 11 (1957): 257-261.
- Venables, A.J. "Trade and Trade Policy with Differentiated Products: A Chamberlinian-Ricardian Model," *The Economic Journal* 97 (September 1987): 700-717.

## Appendix 1. Model Variables and Equations

---

### Endogenous Variables

$$x1_{ij}, x2_{ij}, PI_{1i}, PI_{2i}, p_{1r}, p_{2r}, y_{1r}, y_{2r}, V_r; \quad \forall i = newc, cafl, rous; \forall j = cal, ch, mex; \forall r = cal, ch$$

### Exogenous Variables

$$pop_i, I_{1i}, I_{2i}, m_{1ij}, m_{2ij}, p_{1,mex}, p_{2,mex}; \quad \forall i = newc, cafl, rous; \forall j = cal, ch, mex$$

### Variable Definitions

$x1_{ij}, x2_{ij}$  Quantity of avocado from supply region  $j$  consumed in demand region  $i$  in time periods 1 and 2

$PI_{1i}, PI_{2i}$  Avocado price index in demand region  $i$  in time periods 1 and 2

$p_{1j}, p_{2j}$  Producer price of avocados in supply region  $j$  in time periods 1 and 2

$y_{1r}, y_{2r}$  Supply of avocados from region  $r$  in time periods 1 and 2

$V_r$  Avocado factor endowment utilized in supply region  $r$

$pop_i$  Population in demand region  $i$

$I_{1i}, I_{2i}$  Per capita income in demand region  $i$  in time periods 1 and 2

$m_{1ij}, m_{2ij}$  Fixed marketing margin for avocados from supply region  $j$  in demand region  $i$  in time periods 1 and 2

### Consumer Demand

Time Period 1<sup>a</sup>

$$x1_{ij} = pop_i \left\{ \frac{b_{1i} a_{1ij} (p_{1j} + m_{1ij})^{-\sigma_2} PI_{1i}^{(\sigma_2 - \sigma_1)} I_{1i}}{b_{1i} PI_{1i}^{(1 - \sigma_1)} + (1 - b_{1i})} \right\}, \quad \forall i = newc, cafl, rous^c; \forall j = cal, ch, mex^d$$

Time Period 2<sup>b</sup>

$$x2_{ij} = pop_i \left\{ \frac{b_{2i} a_{2ij} (p_{2j} + m_{2ij})^{-\sigma_2} PI_{2i}^{(\sigma_2 - \sigma_1)} I_{2i}}{b_{2i} PI_{2i}^{(1 - \sigma_1)} + (1 - b_{2i})} \right\}, \quad \forall i = newc, cafl, rous; \forall j = cal, ch, mex$$

### Demand Price Indices

Time Period 1

$$PI_{1i} = \left\{ \sum_j a_{1ij} (p_{1j} + m_{1ij})^{(1 - \sigma_2)} \right\}^{\frac{1}{(1 - \sigma_2)}} \quad \forall i = newc, cafl, rous$$

Time Period 2

$$PI_{2i} = \left\{ \sum_j a_{2ij} (p_{2j} + m_{2ij})^{(1 - \sigma_2)} \right\}^{\frac{1}{(1 - \sigma_2)}} \quad \forall i = newc, cafl, rous$$


---

## Appendix 1. Continued

---

### Conditional Avocado Supply

Time Period 1

$$y_{1r} = \delta_r p_{1r}^{\beta_r - 1} \left\{ \delta_r p_{1r}^{\beta_r} + (1 - \delta_r) p_{2r}^{\beta_r} \right\}^{\frac{1}{\beta_r} - 1} V_r, \quad \forall r = cal, ch$$

Time Period 2

$$y_{2r} = (1 - \delta_r) p_{2r}^{\beta_r - 1} \left\{ \delta_r p_{1r}^{\beta_r} + (1 - \delta_r) p_{2r}^{\beta_r} \right\}^{\frac{1}{\beta_r} - 1} V_r, \quad \forall r = cal, ch$$

### Supply of Avocado Factor Endowment

$$V_r = c_r + d_r \left\{ \delta_r p_{1r}^{\beta_r} + (1 - \delta_r) p_{2r}^{\beta_r} \right\}^{\frac{1}{\beta_r}}, \quad \forall r = cal, ch$$

### Market Clearing Conditions

Time Period 1

$$y_{1r} = \sum_i x_{1ir}, \quad \forall r = cal, ch$$

Time Period 2

$$y_{2r} = \sum_i x_{2ir}, \quad \forall r = cal, ch$$

### Mexican Producer Price

$$p_{1,mex} = p_{2,mex} = \bar{p}$$

---

<sup>a</sup>Time period 1: October 15 to April 15.

<sup>b</sup>Time period 2: April 16 to October 14.

<sup>c</sup>Demand regions: *newc* (Region A), CO, CT, DE, DC, IA, ID, IL, IN, KS, KY, ME, MD, MA, MI, MN, MT, MO, NE, NH, NJ, NY, ND, PA, OH, RI, SD, UT, VT, VA, WV, WI, WY; *rous* (Region B), AL, AZ, AR, GA, LA, MS, NV, NM, NC, OK, OR, SC, TN, TX, WA; *cafl* (Region C), CA, FL, and HI.

<sup>d</sup>Supply regions: *cal*, California; *ch*, Chile; *mex*, Mexico.

## Appendix 2. A Mathematical Description of the Model and Its Calibration

### Demand

To represent the preference structure mathematically, a nested Constant Elasticity of Substitution utility function is used. This functional form is commonly used in empirical models concerning international trade issues. The utility function, uncompensated demand, and price index functions for the nested CES used in this model are defined as:

$$U_i = \left\{ b_i^{\frac{1}{\sigma_1}} \left( \sum_j a_{ij}^{\frac{1}{\sigma_2}} x_{ij}^{\frac{\sigma_2-1}{\sigma_2}} \right)^{\frac{\sigma_2(\sigma_1-1)}{\sigma_1(\sigma_2-1)}} + (1-b_i)^{\frac{1}{\sigma_1}} XE_i^{\frac{\sigma_1-1}{\sigma_1}} \right\}^{\frac{\sigma_1}{\sigma_1-1}}, \sum_j a_j = 1, \quad (1)$$

$$x_{ij} = \frac{b_i a_{ij} (p_{ij} + m_{ij})^{-\sigma_2} P I_i^{(\sigma_2-\sigma_1)} I_i}{b_i P I_i^{(1-\sigma_1)} + (1-b_i) P E_i^{(1-\sigma_1)}}, \text{ and} \quad (2)$$

$$P I_i = \left\{ \sum_j a_{ij} (p_{ij} + m_{ij})^{(1-\sigma_2)} \right\}^{\frac{1}{(1-\sigma_2)}}, \quad (3)$$

where  $x_{ij}$  is the quantity of avocados from the  $j$ th supply region consumed in the  $i$ th demand region,  $XE_i$  is the aggregate quantity of all other goods consumed in the  $i$ th demand region,  $p_{ij}$  is the producer price of avocados from the  $j$ th producer region in the  $i$ th demand region,  $m_{ij}$  is the fixed marketing margin for avocados from the  $j$ th producer region in the  $i$ th demand region,  $P I_i$  is the avocado price index in demand region  $i$ ,  $I_i$  is per capita income in demand region  $i$ ,  $P E_i$  is the aggregate price of the composite “all other goods” category in demand region  $i$ , and  $b_i$  and  $a_{ij}$  are shift parameters.<sup>30</sup> Note that the time subscripts have been suppressed to simplify the notation.

### Supply

Assuming that avocado producers maximize revenues, subject to a Constant Elasticity of Transformation production possibility frontier, a CET revenue function may be derived and is defined as:

$$R_j(p, V) = \left\{ \delta_j p_{1j}^{\beta_j} + (1-\delta_j) p_{2j}^{\beta_j} \right\}^{\frac{1}{\beta_j}} V_j, \quad (4)$$

where  $R_j$  is the total revenue in the  $j$ th producer region across both time periods,  $p_{1j}$  and  $p_{2j}$  are the producer prices of avocado in the  $j$ th region in Periods 1 and 2 respectively, and  $V_j$  is the level of factor endowment used in avocado production in the  $j$ th region. Note that the level of  $V_j$

<sup>30</sup> The values of the shift parameters  $a_{ij}$  and  $b_i$  are chosen such that the empirical model replicates an observed initial equilibrium.

determines the position of the production possibility frontier in output space and thus the position of the revenue function in price space. As more factors of production flow into the avocado industry in a given supply region, more avocados can be produced in both time periods and the production possibility frontier shifts out.

The conditional avocado supply function for each time period is derived by taking the first derivative of the CET revenue function with respect to the producer price for that time period.

$$\frac{\partial R_j}{\partial p_{1j}} = y_{1j}^c = \delta_j p_{1j}^{\beta_j-1} \left\{ \delta_j p_{1j}^{\beta_j} + (1-\delta_j) p_{2j}^{\beta_j} \right\}^{\frac{1}{\beta_j}-1} V_j \text{ and} \quad (5)$$

$$\frac{\partial R_j}{\partial p_{2j}} = y_{2j}^c = (1-\delta_j) p_{2j}^{\beta_j-1} \left\{ \delta_j p_{1j}^{\beta_j} + (1-\delta_j) p_{2j}^{\beta_j} \right\}^{\frac{1}{\beta_j}-1} V_j, \quad (6)$$

where  $y_{1j}^c$  and  $y_{2j}^c$  are the conditional supply of avocados in Periods 1 and 2 from the  $j$ th region,  $V_j$  is the level of avocado factor endowment in the  $j$ th region,  $\delta_j$  is a shift parameter, and  $\beta_j$  is a parameter that determines the elasticity of transformation. These supply functions are considered “conditional” because the level of factor endowment is held constant.

However, the level of avocado factor endowment in each region is a function of the overall producer price level, holding production costs constant. An increase in the overall avocado producer price will encourage expanded production, which will require an increase in the amount of the avocado factor endowment employed. The level of  $V_j$  employed in the  $j$ th region is assumed to be a linear function of the avocado producer price index:

$$V_j = c_j + d_j PP_j, \quad (7)$$

where  $PP_j$  is the avocado producer price index in the  $j$ th region, and  $c_j$  and  $d_j$  are parameters. The producer price index for a CET revenue function is defined as:

$$PP_j = \left\{ \delta_j p_{1j}^{\beta_j} + (1-\delta_j) p_{2j}^{\beta_j} \right\}^{\frac{1}{\beta_j}}. \quad (8)$$

Thus, the producer price index is a function of prices in both time periods. Note that the aggregate supply response in each region is determined by the responsiveness in equation (7) to a change in the producer price index.

## Model Equations

Appendix 1 provides a list of all of the equations in the model. In addition to the equations discussed above, there are two additional equations that ensure the avocado market is in equilibrium, or “clears” in each time period. Note that the since the demand equations are for a representative consumer, they are multiplied by population to obtain the total amount of avocados consumed in each time period. Also, because the aggregate price of “all other goods” is held constant (due to partial equilibrium assumption), its value is arbitrarily set equal to one.

This choice does not affect the model results. Choosing a different value for  $PE_i$  would rescale the calibrated value of the  $b_i$  parameter.

### Model Calibration

We use the inverse demand for California avocados estimated by Carman and Craft (1998) to determine demand elasticities at the producer level, as described in section 2. We define the wholesale own-price demand elasticity ( $\varepsilon_w$ ) and the producer level own-price elasticity ( $\varepsilon_p$ ) as:

$$\varepsilon_w = \frac{\partial Q}{\partial p_w} \frac{p_w}{Q} \text{ and } \varepsilon_p = \frac{\partial Q}{\partial p_p} \frac{p_p}{Q},$$

where  $p_w$  is the wholesale price,  $p_p$  is the producer price, and  $Q$  is the common quantity level. If the marketing margin is constant, then the slope of the wholesale ( $D_w$ ) and the derived producer level ( $D_p$ ) demand functions are the same. Then the relationship between these two elasticities can be expressed as:

$$\varepsilon_w = \varepsilon_p \frac{Q}{p_p} \frac{p_w}{Q} = \varepsilon_p \frac{p_w}{p_p}.$$

Because the aggregate demand curve may be thought of as the horizontal summation of the individual demand curves for avocados from the supply regions, at a constant price the aggregate own-price demand elasticity will be smaller in absolute terms than the individual own-price demand elasticities due to a larger quantity. Assuming that the slopes of the aggregate demand curve and the demand curve for California avocados are equal, then the relationship between the aggregate ( $\varepsilon_A$ ) and California ( $\varepsilon_{cal}$ ) own-price demand elasticity is:

$$\varepsilon_A = \varepsilon_{cal} \frac{Q_{cal}}{Q_A},$$

where  $Q_{cal}$  is the quantity of California avocados and  $Q_A$  is the aggregate or total quantity of avocados sold.

Based on the nested CES demand structure (figure 2 in section 2), the formulas for the own-price Allen partial elasticities of substitution (AEOS) are (Keller 1980):

$$\sigma_{AA} = -\sigma_1 (s_A^{-1} - 1), \text{ and} \tag{9}$$

$$\sigma_{cal,cal} = -\left[ \sigma_2 (s_{cal}^{-1} - s_A^{-1}) + \sigma_1 (s_A^{-1} - 1) \right], \tag{10}$$

where  $\sigma_{AA}$  is the aggregate own-price AEOS,  $s_A$  is the budget share of avocados,  $\sigma_{cal,cal}$  is the own-price AEOS for California avocados, and  $s_{cal}$  is the budget share of California avocados.

Using equation (9), the elasticity form of the Slutsky decomposition, and the homotheticity of the CES utility function, one can determine the value of  $\sigma_I$ :

$$\varepsilon_A = s_A (\sigma_{AA} - \eta_A) = s_A \left[ -\sigma_1 (s_A^{-1} - 1) - 1 \right] = -\sigma_1 + s_A (\sigma_1 - 1), \text{ thus}$$

$$\sigma_1 = \frac{\varepsilon_A + s_A}{s_A - 1}. \quad (11)$$

Once the value of  $\sigma_I$  has been determined, then substituting into equation (10) and using the Slutsky decomposition:

$$\varepsilon_{cal} = s_{cal} \left\{ - \left[ \sigma_2 (s_{cal}^{-1} - s_A^{-1}) + \sigma_1 (s_A^{-1} - 1) \right] - 1 \right\}.$$

Solving for  $\sigma_2$  yields:

$$\sigma_2 = \frac{s_A \left\{ \varepsilon_{cal} + s_{cal} \left[ 1 + \sigma_1 (s_A^{-1} - 1) \right] \right\}}{s_{cal} - s_A}. \quad (12)$$

Because the flexibility estimate from Carman and Craft is based on annual, national data, the budget shares in equations (11) and (12) are averages across both time periods and the three demand regions in the baseline data. The calibrated values of  $\sigma_I$  and  $\sigma_2$  are reported in appendix 2 table 1, along with the implied uncompensated demand elasticities for avocados from the three supply regions in the three demand regions and two time periods.<sup>31</sup> Note that avocados from Mexico are only available in Region A during Period 1.

The income elasticities from a CES utility function are all equal to one. This raises the question of whether this is a valid assumption. Carmen and Craft estimated that the producer price flexibility with respect to income equaled 2.77 when evaluated at the mean of their sample. Using this information, along with estimated own-price flexibility, it is possible to determine the implied producer level income elasticity for California avocados. Using the own-price flexibility and the mean price (\$0.563 per pound) and quantity (1.198 pounds per capita), the slope of the inverse demand function, using the definition of the price flexibility, is equal to:

$$\frac{\partial p}{\partial Q} = -1.605 \frac{0.563}{1.198} = -0.754.$$

The slope of the demand function is then the reciprocal of this value, or  $-1.326$ . Next, using the price flexibility with respect to income, a one percent increase in per capita income will increase

---

<sup>31</sup> The cross-price AEOS between avocados by producer region, which are all equal by definition of the CES function, are calculated based on the following formula from Keller:  $\sigma_{ij} = \sigma_2 s_A^{-1} - \sigma_1 (s_A^{-1} - 1)$ .

Appendix 2 Table 1. Calibrated Values of  $\sigma_1$  and  $\sigma_2$  and Implied Price Elasticity of Demand Values

<i>Elasticities of Substitution</i>	$\sigma_1$ 0.6	$\sigma_2$ 1.9	
<i>Base Demand Elasticities</i>		<u>Supply Region</u>	
Region A, Period 1	<i>California</i>	<i>Chile</i>	<i>Mexico</i>
<i>California</i>	-1.62	0.19	0.84
<i>Chile</i>	0.28	-1.71	0.84
<i>Mexico</i>	0.28	0.19	-1.06
Region A, Period 2	<i>California</i>	<i>Chile</i>	
<i>California</i>	-0.86	0.26	
<i>Chile</i>	1.04	-1.64	
Region B, Period 1	<i>California</i>	<i>Chile</i>	
<i>California</i>	-1.18	0.58	
<i>Chile</i>	0.72	-1.32	
Region B, Period 2	<i>California</i>	<i>Chile</i>	
<i>California</i>	-0.87	0.27	
<i>Chile</i>	1.03	-1.63	
Region C, Period 1	<i>California</i>	<i>Chile</i>	
<i>California</i>	-1.15	0.55	
<i>Chile</i>	0.75	-1.35	
Region C, Period 2	<i>California</i>	<i>Chile</i>	
<i>California</i>	-0.86	0.26	
<i>Chile</i>	1.04	-1.64	

the producer price of California avocados by 2.77 percent, or an increase of \$0.0156 when evaluated at the sample means. Because by definition, the income elasticity is computed holding price constant, the effect of a change in income on the quantity demanded is computed by using the slope of the demand function and a price decrease of \$0.0156. This yields an increase in per capita consumption of 0.021 pounds, or a 1.7 percent increase in the mean value. Thus, the implied producer level income elasticity from Carman and Craft is 1.7, and CES income elasticities equal to one appear to be conservative in comparison.

For the parameters  $a_{1ij}$  and  $a_{2ij}$ , a system of  $r$  conditional demand equations, where  $r$  equals the number of avocado from each producer region consumed in each demand region in each time period, is solved. (Only  $r$  equations need to be solved since the requirement that the  $a_{ij}$ 's must sum to one in each demand region and time period is imposed.) These equations are conditional because expenditures on all avocados are held constant. For each demand region and time period, the following system of equations is solved to determine the values of  $a_{1ij}$  and  $a_{2ij}$ :

$$\frac{x_{ir}}{pop_i} = \frac{a_{ir} (p_{ir} + m_{ir})^{-\sigma_2} EXP_i}{\left[ \sum_r a_{ir} (p_{ir} + m_{ir})^{1-\sigma_2} \right] + \left( 1 - \sum_r a_{ir} \right) (p_{ij} + m_{ij})^{1-\sigma_2}} \quad \forall r = 1, \dots, j-1, \quad (13)$$

where  $EXP_i$  is per capita expenditure on avocados from all supply regions in the  $i$ th demand region.

The values of the parameters  $b_{1i}$  and  $b_{2i}$  are determined in a similar manner. Because only one value needs to be chosen for each demand region and time period (a total of six values), the following single equation is solved for each value of  $b_i$ :

$$QI_i = \frac{b_i PI_i^{-\sigma_1} I_i}{b_i PI_i^{1-\sigma_1} + (1-b_i)}, \quad (14)$$

where  $QI_i$  is the CES quantity aggregator which is defined as:

$$QI_i = \left\{ \sum_j a_{ij}^{1/\sigma_2} x_{ij}^{\frac{(\sigma_2-1)}{\sigma_2}} \right\}^{\frac{\sigma_2}{(\sigma_2-1)}}.$$

The calibrated values of,  $a_{1ij}$ ,  $a_{2ij}$ ,  $b_{1i}$ , and  $b_{2i}$  are reported in appendix 2 table 2.

Appendix 2 Table 2. Calibrated Base Shift Parameters

	<u>Supply Region</u>		
	<i>California</i>	<i>Chile</i>	<i>Mexico</i>
$a_{1ij}$			
<i>Region A</i>	0.2610527920	0.1378315772	0.6011156308
<i>Region B</i>	0.5955227247	0.4044772753	0.0
<i>Region C</i>	0.6295160192	0.3704839808	0.0
$a_{2ij}$			
<i>Region A</i>	0.8244000185	0.1755999815	0.0
<i>Region B</i>	0.8170727337	0.1829272663	0.0
<i>Region C</i>	0.8253926647	0.1746073353	0.0
	<u>Demand Region</u>		
	<i>Region A</i>	<i>Region B</i>	<i>Region C</i>
$b_{1i}$	0.0000377758	0.0000975441	0.0001358033
$b_{2i}$	0.0000435652	0.0001104222	0.0001769079

## Revenue Function Parameters and Avocado Factor Endowment

The parameters  $\delta_r$  and  $\beta_r$  as well as the value of  $V_r$  must be chosen to calibrate the revenue functions for California and Chile. The value of  $\beta_r$  determines the elasticity of transformation or the ease with which avocado producers can shift their sales between the two time periods as relative producer prices of avocados between the periods change. The elasticity of transformation,  $\sigma_{Tr}$ , is defined as:

$$\sigma_{Tr} = (1 - \beta_r), \quad \beta_r \geq 1 \text{ and } \forall r = cal, ch \quad (15)$$

No empirical estimates exist for the elasticity of transformation. It is assumed to be relatively small because historical seasonal production patterns have persisted over time even though avocados can be left on the tree for an extended period before harvesting. A base value of  $-0.5$  for both regions, implying that  $\beta_r$  equals 1.5, is used in the model.

Given this value of  $\beta_r$ , the values of  $\delta_r$  and  $V_r$  are chosen so that the seasonal production patterns and the overall level of avocado production are replicated for the California and Chile supply regions. This is accomplished by substituting initial producer prices and production for each time period into equations (5) and (6) and solving that system of two equations for  $\delta_r$  and  $V_r$ . The calibrated values of the parameters of the revenue functions and  $V_r$  for California and Chile are listed in appendix 2 table 3.

In this model, the aggregate supply elasticity ( $\eta_{Ar}$ ) is defined as:

$$\eta_{Ar} = \frac{\partial V_r}{\partial PP_r} \frac{PP_r}{V_r} = d_r \frac{PP_r}{V_r}. \quad (16)$$

With a known value of  $\eta_{Ar}$ , equation (16) can then be used to determine the value of the parameter  $d_r$ . Given a value for  $d_r$ , the value of the parameter  $c_r$  can be calculated by solving:

$$c_r = V_r - d_r PP_r. \quad (17)$$

Values of the parameters  $c_r$  and  $d_r$  for California and Chile are listed in appendix 2 table 3.

Appendix 2 Table 3. Revenue Function and Factor Supply Parameters

<i>Revenue Function Parameters</i>	$\delta$	$\beta$	$V_r$
California	0.3612415860	1.5	347.05186946
Chile	0.6164967285	1.5	176.82890923
<i>Factor Supply Parameters</i>	$C$	$d$	
California	225.58371515	118.98387140	
Chile	63.73595678	193.23057749	

### Appendix 3. Baseline Quantity and Price Data

Table 1. Quantities of Hass avocados supplied by California, Chile, and Mexico, by time period and demand region, October 15, 2001 to October 15, 2003, pounds

#### Time Period 1

	Demand Region A (northeastern and central States)			
	California <sup>1</sup>	Chile <sup>2</sup>	Mexico <sup>2</sup>	TOTAL
10/15/01 to 4/15/02	16,532,888	11,540,763	52,314,712	80,388,362
10/15/02 to 4/15/03	11,697,688	14,196,303	64,178,417	90,072,408
	Demand Region B (Pacific and southern States, except CA, FL, and HI)			
	California <sup>1</sup>	Chile <sup>2</sup>	Mexico <sup>2</sup>	TOTAL
10/15/01 to 4/15/02	52,353,000	36,544,950	0	88,897,950
10/15/02 to 4/15/03	47,510,300	57,658,459	0	105,168,759
	Demand Region C (California, Florida, and Hawaii)			
	California <sup>1</sup>	Chile <sup>2</sup>	Mexico <sup>2</sup>	TOTAL
10/15/01 to 4/15/02	56,588,225	39,501,344	0	96,089,569
10/15/02 to 4/15/03	46,947,050	56,974,899	0	103,921,949

#### Time Period 2

	Demand Region A (northeastern and central States)			
	California <sup>1</sup>	Chile <sup>2</sup>	Mexico <sup>2</sup>	TOTAL
4/16/02 to 10/14/02	65,524,750	14,873,603	0	80,398,353
4/16/03 to 10/14/03	57,455,550	21,795,530	0	79,251,080
	Demand Region B (Pacific and southern States, except CA, FL, and HI)			
	California <sup>1</sup>	Chile <sup>2</sup>	Mexico <sup>2</sup>	TOTAL
4/16/02 to 10/14/02	83,453,850	18,943,368	0	102,397,218
4/16/03 to 10/14/03	72,417,688	27,471,357	0	99,889,044
	Demand Region C (California, Florida, and Hawaii)			
	California <sup>1</sup>	Chile <sup>2</sup>	Mexico <sup>2</sup>	TOTAL
4/16/02 to 10/14/02	96,748,375	21,961,120	0	118,709,495
4/16/03 to 10/14/03	84,792,550	32,165,711	0	116,958,261

(sources and notes, next page)

## Appendix 3. Continued

Table 1. Continued

Sources: California quantities: based on data provided by the Avocado Marketing Research and Information Center (AMRIC). Chile and Mexico quantities: U.S. Census Bureau, as reported in the World Trade Atlas.

<sup>1</sup> AMRIC data are reported for terminal markets located within the six regions: Northeast, East Central, West Central, Pacific, Southwest, and Southeast. States currently approved to receive Hass avocados from Mexico (Region A) correspond to those having terminal markets in AMRIC's Northeast, East Central, and West Central regions, plus Idaho and Utah. States in the Pacific, Southwest, and Southeast regions, minus California, Florida, Hawaii, Idaho, and Utah, comprise Region B. Region C is composed of California, Florida, and Hawaii. April and October quantities are divided evenly between the two time periods.

<sup>2</sup> We do not know the market destinations of avocado imports from Chile. For each time period, regional quantities from Chile are assumed to be proportional to regional shipments reported for California. As with the California supply, April and October quantities supplied by Chile are divided evenly between the two time periods. For imports from Mexico, April and October quantities are fully included within Period 1, given the relatively small amounts that are otherwise exported to Alaska (the only State allowed to receive Hass avocado imports from Mexico year-round) or processed. May through September shipments (imports of fresh avocados into Alaska and imports of processed avocados) are excluded from the analysis.

### Appendix 3. Continued.

Table 2. Baseline Data Used in the Model

Quantity Demanded	Supply Region		
	California	Chile	Mexico
Time Period 1		Million Pounds	
<i>Region A</i>	14.1152875	12.86853314	58.24656427
<i>Region B</i>	49.9316500	47.10170482	0
<i>Region C</i>	51.7676375	48.23812189	0
Time period 2			
<i>Region A</i>	61.4901500	18.33456665	0
<i>Region B</i>	77.9357687	23.20736215	0
<i>Region C</i>	90.7704625	27.06341546	0
Wholesale Prices			
Time period 1		Dollars per Pound	
<i>Region A</i>	1.4702	1.1029	1.0815
<i>Region B</i>	1.5542	1.3075	N/A
<i>Region C</i>	1.4710	1.1550	N/A
Time period 2			
<i>Region A</i>	1.7438	1.4609	N/A
<i>Region B</i>	1.7294	1.4884	N/A
<i>Region C</i>	1.6864	1.4077	N/A
Producer prices			
Time period 1	0.8712	0.5767	0.6872
Time period 2	1.1008	0.5990	N/A
		Demand Region	
	<i>Region A</i>	<i>Region B</i>	<i>Region C</i>
Per-capita income			
Time period 1	\$16,483.10	\$14,080.46	\$16,207.59
Time period 2	\$16,871.37	\$14,244.74	\$16,659.23
		Millions	
Population	147.920	87.479	53.348

Sources: Demand quantities: averages of quantities shown in appendix 3 table 1. Wholesale prices: Market News Archive, USDA Agricultural Marketing Service, Wholesale Market Fruit Reports (various issues). Producer prices: California producer prices are prices "out the packinghouse door" reported by the California Avocado Commission, and Chilean and Mexican prices are unit import prices reported by USDA FAS. Per capita income: State quarterly personal income from U.S. Department of Commerce, Bureau of Economic Analysis. Population: mid-year State population estimates from U.S. Census Bureau.

#### Appendix 4. Approach Used for the Sensitivity Analysis

The sensitivity analysis is performed using symmetric order three Gaussian quadratures. Stroud (1957) has shown that for a symmetric distribution, such as the uniform or triangular, the model needs to be resolved only  $2n$  times, where  $n$  is the number of exogenous variables or parameters, in order to conduct a systematic sensitivity analysis. Arndt and Hertel (1997) have shown that systematic sensitivity analyses conducted using order three quadratures are as accurate as higher order quadratures.

Values for the random exogenous variables (or parameters) are chosen using the following procedure. Let  $n$  be the number of exogenous variables to be included in the sensitivity analysis. Then let  $\Gamma_k = (\gamma_{k1}, \gamma_{k2}, \dots, \gamma_{kn})$  be the  $k$ th quadratures point, where  $k = 1, 2, \dots, 2n$ . Then define an integer  $r = 1, 2, \dots, z$  such that  $z$  does not exceed  $n/2$ . For example, if  $n$  equals 5, then  $r$  would equal 2 because  $r$  cannot exceed  $5/2$ . Elements of the  $\Gamma$  matrix are then chosen using the following formulas:

$$\gamma_{k,2r-1} = \sqrt{2} \cos \left[ \frac{(2r-1)k\pi}{n} \right], \text{ and} \quad (19)$$

$$\gamma_{k,2r} = \sqrt{2} \sin \left[ \frac{(2r-1)k\pi}{n} \right]. \quad (20)$$

Note that if  $n$  is an odd number, then  $\gamma_{kn} = (-1)^k$ . The values of the random exogenous variables for each quadratures point are then determined using the following formula:

$$\Phi = \mu + \Gamma\sqrt{\Sigma}, \quad (21)$$

where  $\Phi$  is a  $(2n \times n)$  matrix of values for the exogenous variables,  $\mu$  is a  $(2n \times n)$  matrix of the means of the exogenous variables,  $\Gamma$  is a  $(2n \times n)$  matrix defined above, and  $\Sigma$  is a  $(n \times n)$  diagonal variance/covariance matrix for the exogenous variables. Note that if all of the exogenous variables are independent, as is assumed here, then  $\Sigma$  will be a diagonal matrix.

## Appendix 5. Equivalent Variation

Equivalent variation is defined as:

$$EV = e(p^0, u^1) - e(p^0, u^0)$$

where  $e$  is the expenditure function,  $p^0$  is the base or current price vector,  $u^0$  is the base level of utility, and  $u^1$  is the level of utility obtained by removing restrictions on Mexican avocado imports. The expenditure function is derived from the utility function (appendix 2 equation 1) and is defined for the representative consumer from the  $i$ th demand region as:

$$e_i(p_i, u_i) = \left\{ b_i \left( \sum_j a_{ij} [p_{ij} + m_{ij}]^{1-\sigma_2} \right)^{\frac{1-\sigma_1}{1-\sigma_2}} + (1-b_i) PE^{1-\sigma_1} \right\}^{\frac{1}{1-\sigma_1}} u_i. \quad (22)$$

Note that since the expenditure function is linear in utility, EV for the representative consumer can be expressed as:

$$EV_i = \left\{ b_i \left( \sum_j a_{ij} [p_{ij}^0 + m_{ij}]^{1-\sigma_2} \right)^{\frac{1-\sigma_1}{1-\sigma_2}} + (1-b_i) (PE^0)^{1-\sigma_1} \right\}^{\frac{1}{1-\sigma_1}} (u_i^1 - u_i^0), \quad (23)$$

where base period prices and utility are denoted by a 0 superscript. The base level of utility and the level of utility after the lifting of the import restrictions may be computed from the indirect utility function, which is derived from equation (23). To obtain the total level of EV, equation (23) is multiplied by the population in the  $i$ th demand region.